POWER

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The Coal Business Is Charged with Public Interest

THE most fundamental problem in social economics now in sight, and one that will loom larger the nearer we get to it, is that which comes from the private ownership of natural resources.

Civilized man has an ingrained reverence for property rights and his courts a veneration for vested interests.

But there is a growing realization of the fact that the public weal is superior to individual interest and that financial strength and strategic advantage must not be used to the general harm.

The report of the United States Coal Commission on Anthracite is a heartening utterance to those who are looking for the abolition of such abuses.

"The fundamental fact in the anthracite coal problem is that heretofore these limited and exhaustible natural deposits have been in the absolute private possession of their legal owners, to be developed or withheld at will, to be leased for such royalties as could be exacted, to be transported and distributed at such rates and in such manner as a double-headed railroad and coal combination might find most advantageous from the point of view of private profit, to be sold at such prices as could be maintained by the restriction of output and the elimination of independent competitors, through such means as the maintenance of freight rates burdensome except to those who, owning both mines and railroads, could afford to be indifferent as to whether their revenue came from the one source or the other."

When this and the other conclusions of the report to which it is introductory are admitted and appreciated, it will be comparatively easy to construct a model upon which the owner may be assured of the ultimate return of all the capital actually invested, with a reasonable interest for the time it has been locked up, the operator a fair profit for his enterprise, and everybody who works, from the executive down to the mule driver, a generous wage commensurate with the service actually rendered.

Records of Elevator Cable Operation Show Wide Differences in Life of Cables

Careful Records Kept of Cable Operation Over a Period of Nine Years—Tests Made on a Number of Cables Removed to Determine Their Condition

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LITTLE definite information is available on elevator-cable operation, that would make possible intelligent conclusions as to the factors that influence the life of cables. During the last nine years careful records have been kept of elevator-cable performance on the twelve elevators in the Union Central Life Insurance Company's Building, Cincinnati, Ohio. This building is 495 ft. high from the main entrance and 535 ft. from the sub-basement and the distance each elevator travels is given in Table I. Not only has a record of cable life been kept, but sections of the cables removed have been taken apart and a careful study made as to their condition. Sections of the cables have been tested to determine their breaking strength after removal from service. In no case, in these tests, did the cables show a reduction in ultimate strength of more than 15 per cent, and in one test a section of cable 3 ft. long showed a higher breaking strength than given it by the manufacturers when new. In the cables the number of breaks in the individual wires varied from 6 to 230 in a 3-ft. length. These cases are shown in detail farther on in the report.

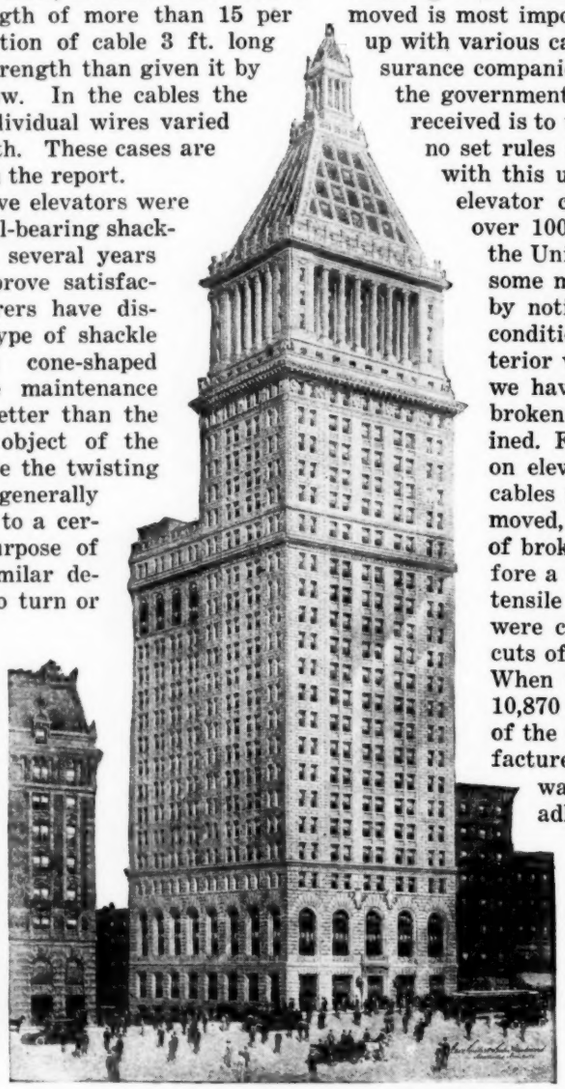
All the cables on the twelve elevators were originally equipped with ball-bearing shackles, but they were removed several years ago because they did not prove satisfactory. Elevator manufacturers have discontinued the use of this type of shackle and have substituted a cone-shaped socket, which reduces the maintenance cost, and the principle is better than the ball-bearing design. The object of the ball bearing is not to reduce the twisting strain on the cable, as is generally supposed—although it does to a certain extent. The main purpose of the ball-bearing cone or similar device is to allow the cables to turn or twist to their proper position if they get slack. If a cable became slack with a fixed shackle fastening, the probabilities are that a kink would be formed in the cable, and if it should get a sudden strain, a break would occur in the kinked part. The elevators under discussion are equipped with cable equalizers, which automatically adjust the tension on all hoisting cables, equalizing the load on each.

The wear on the cables was determined by using a micrometer on the individual wire and their reduction in size due to wear noted.

The compensating cables are arranged in the usual way and run around a 32-in. sheave wheel at the bottom of the hatchway. As the only load these cables have to carry is their own weight plus the weight of the sheave wheel, it would be natural to expect that their life would greatly exceed that of the hoisting cables. These cables, are removed when they are worn to such an extent that a strand might break in any of the five cables. A life of 82,744, 83,473 and 93,228 car miles was obtained for the three sets removed up to the time of making this report. They are 6x19, ⅝-in. iron and were removed from elevators Nos. 6, 7 and 8, all of which are high-rise cars.

Making a decision as to when cables should be removed is most important. We have taken this matter up with various cable manufacturers and elevator insurance companies and have also received data from the government, and the substance of all answers received is to use our own judgment, as there are no set rules regarding this matter. Therefore, with this uncertainty about the useful life of elevator cables, we are having a series of over 100 elevator-cable tests, conducted at the University of Cincinnati, to determine some means of finding a factor of safety by noting the wear, breaks and external conditions of the wires, assuming all interior wires in good condition. Thus far, we have never found any interior wires broken in any cable that has been examined. For instance, as shown in the report on elevator No. 6, the 6x19 iron hoisting cables made 37,452 miles before being removed, because it was thought the numbers of broken wires made this necessary. Before a sample of this cable was tested for tensile strength three additional wires were cut in each outer strand, and these cuts of three wires were two inches apart. When this cable was tested, it developed 10,870 lb. maximum strength before any of the strands started to fail. The manufacturer's rating on this cable, when new, was 12,000 lb. It is a good policy to adhere to the safety-first principle when ordering new cables, nevertheless the majority of elevator inspectors condemn cables whose condition does not justify their renewal.

Some nine years' experience with 45 sets of hoisting cables and 52 governor cables, as tabulated in Tables III and IV, leads to the opinion that more scientific study must be given by



UNION CENTRAL LIFE INSURANCE BUILDING

wire-cable manufacturers to the construction of elevator cables. From observation, not one of any of the six different makes of cables that were taken off, or those now in service, which did not show more broken wires in the cables in the first six months of use than in the following twelve months of service. The tension on each wire in the strands, when made by the manufacturer, is not uniform. Consequently, when the load is placed on the cables, the wires subjected to the greatest tension fail in the action of the cable's elongation.

The outer or cover wires are those wires around the 7 center wires which complete the strand. These cover wires are the ones that break and do so on the outside

TABLE I—CAR TRAVEL AND LENGTH OF CABLES

Car No.	Floors	Travel, Feet	Motor on Floor	Approx. Length in Feet—Hoisting Cables	Approx. Length in Feet—Governor Cables
1	B. to 17th	236	19th	300	556
2	S.B. to 17th	262	18th	332	586
3	B. to 17th	236	19th	300	556
4	B. to 17th	236	18th	286	576
5	S.B. to 28th	417	29th	486	876
6	B. to 28th	391	29th	445	865
7	B. to 28th	391	29th	444	865
8	B. to 28th	391	29th	444	865
9	B. to 17th	236	18th	248	575
10	B. to 17th	236	19th	305	556
11	B. to 17th	236	18th	248	556
12	B. to 17th	236	19th	305	556

B—Basement; S.B.—Sub-basement.

of the lay. None of these wires was found to be broken on the core side of the strand. The drum or sheave wheel undoubtedly has an influence on the life of the cable. The stress caused by bending or stretching of the cable over the high part of the sheave causes it to pull apart or break, because the cable is of too rigid construction and probably needs lubrication. What happens is that it has a tendency to throw the strain on the top strands of the cables passing over the sheave and buckle the under wires which are against the sheave. The center 7 wires of the 19 in each strand ride without breaking, because they are not subjected to the bending stresses that the outside wires receive. A 6x19 wire cable construction is not flexible enough to give satisfactory service.

Crystallization, in its full meaning, does not seem to be the real factor that causes the wires to break, from the results of tests made on broken wires in the cables. When testing these wires, they were held between the fingers and bent as far as possible in one direction and

TABLE II—AVERAGE LIFE OF HOISTING CABLES

Material	Four Cars High: No. Cables (Set of Six)	Four Cars High: Total Miles	Four Cars High: Average Miles	Eight Cars Low: No. Cables (Set of Six)	Eight Cars Low: Total Miles	Eight Cars Low: Average Miles
Traction steel	5	143,534	28,707	8	104,963	13,120
Sweeds iron	2	45,118	22,559	1	7,168	7,168
Iron	3	81,746	27,248	5	76,606	15,321
Steel	1	6,963	6,963	4	29,187	7,297
Mild steel	1	35,565	35,565	0	.....	.....
Total	12	312,926		18	217,924	
Average mileage per cable			26,077			12,107
Average life			2 years 9 months 4 days			2 years 7 months 21 days

then back in the other direction until the ends practically touched each other. It was found by these tests that all the short pieces of wire that were supposed to be crystallized showed just the opposite results, and in some cases it took more bending to break them than those that had no signs of defects. It is evident that there are elements that enter into the cable life other than crystallization. The iron 6x19 cables, which are more flexible than steel 6x19, gave longer life and service. We have placed in service 8x19 mild-steel cables, as these are considered superior to 6x19, ⅝-in. iron cables because they give greater flexibility with the necessary strength. After the installation of the 8x19 cables is made, their condition is noted each month as to elongation, broken wires, mileage and general wear that takes place under the regular working conditions.

It will be seen from Table III that, in general, a greater mileage is obtained for the cables on the high-rise cars that run to the tower, namely, Nos. 5, 6, 7 and 8—than on the elevators that go to the 17th floor—Nos. 1, 2, 3, 4, 9, 10, 11 and 12, known as the low-rise cars. The reason that better service life is obtained from the high-rise car cables is that they are longer, consequently it takes fewer trips to make a mile than on the low-rise cars. The high-rise cars travel 6.75 round trips in the shaft, to make a mile, while the low-rise cars make 11.2 round trips. The result is that the cables on the low-rise cars bend more per mile than those on the

TABLE III—RECORD OF ⅝-IN. HOISTING CABLES

Elev. No.	Size, ⅝ in.	Material	Date Installed	Date Removed	Mileage
1	6x19	T.S.	6/15/13	5/28/15	10,247
1	6x19	S.I.	5/28/15	11/ 3/16	7,168
*1	6x19	S.S.	11/ 3/16	.....	27,549
2	6x19	T.S.	6/15/13	7/ 9/15	9,158
2	6x19	S.S.	7/ 9/15	2/15/17	5,732
2	6x19	I.	2/15/17	2/28/22	18,604
*2	8x19	S.	2/28/22	.....	2,883
3	6x19	T.S.	6/15/13	1/21/16	13,192
3	6x19	I.	1/21/16	7/13/18	12,019
3	6x19	I.	7/13/18	2/27/22	16,113
*3	8x19	M.S.	2/27/22	.....	2,888
4	6x19	T.S.	6/15/13	11/ 6/17	17,209
4	6x19	I.	11/ 6/17	2/23/22	16,384
*4	6x19	I.	2/23/22	.....	2,709
5	6x19	T.S.	4/15/13	9/ 8/15	19,991
5	6x19	S.	9/ 8/15	7/ 7/16	6,693
5	6x19	S.I.	7/ 7/16	7/31/19	24,653
5	6x19	I.	7/31/19	3/27/22	21,506
*5	8x19	M.S.	3/27/22	.....	4,028
6	6x19	T.S.	4/10/13	10/30/17	42,568
6	6x19	I.	10/30/17	3/29/22	37,452
*6	8x19	M.S.	3/29/22	.....	4,899
7	6x19	T.S.	6/ 1/13	10/14/14	13,538
7	6x19	T.S.	10/14/14	7/ 5/16	19,346
7	6x19	M.S.	7/ 5/16	7/ 1/20	35,565
*7	6x19	M.S.	7/ 1/20	.....	19,728
8	6x19	T.S.	5/ 1/13	10/31/17	48,091
8	6x19	I.	10/31/17	3/12/20	22,787
8	6x19	I.	3/12/20	5/22/22	20,465
*8	8x19	M.S.	5/22/22	.....	4,039
9	6x19	T.S.	6/15/13	11/ 1/17	18,279
9	6x19	I.	11/ 1/17	2/21/23	21,478
9	6x19	M.S.	2/23/23	.....	.....
10	6x19	T.S.	6/15/13	10/20/14	5,723
10	6x19	S.	10/20/14	3/12/17	12,733
10	6x19	I.	3/12/17	1/13/20	13,487
*10	6x19	I.	1/13/20	.....	13,038
11	6x19	T.S.	6/15/13	11/ 5/17	23,038
11	6x19	I.	11/ 5/17	11/15/23	25,515
11	8x19	M.S.	11/25/23	.....	.....
12	6x19	T.S.	6/15/13	1/ 2/15	8,115
12	6x19	S.	1/ 2/15	12/ 4/15	4,714
12	6x19	S.	12/ 4/15	2/27/17	6,008
12	6x19	I.	2/27/17	2/14/23	26,977
12	8x19	M.S.	2/14/23	.....	.....

* Readings to Nov. 1, 1922, except Nos. 9, 11 and 12.

T.S. = Traction steel; S.I. = Sweeds iron; S.S. = Special steel; M.S = Mill steel; I = Iron; S = Steel.

high-rise cars. The comparison of the average life of 12 sets of cables on high-rise cars with 18 sets on low-rise cars, Table II, shows that the cables on the high-rise cars have more than twice the life of the cables on the low-rise cars; namely, 26,007 miles against 12,107 miles. However, the average periods of operating life are about the same, 2 years, 9 months and 4 days for the high-rise cars against 2 years, 7 months and 21 days for the low-rise cars. On the low-rise cars the traction and secondary sheaves are 34 in. in diameter, with a car speed of 550 ft. per min., whereas on the high-rise cars the traction and secondary sheaves are 36 in. diameter, with a car speed of 750 ft. per minute.

Lubrication of the cables is essential and is another factor that prolongs their life, as it reduces friction in the cable strands as they pass over the sheaves. Manufacturers when making wire cables treat the rope core with lubrication, and some also treat the cable with lubricants before shipment. The more oily matter it contains the better it is for the cable. After a cable has been in service, say for six months, and does not show

sufficient oily appearance, it is our practice to apply a good cable lubricant prepared especially for this purpose, which is free from acid. Lack of lubrication in a cable means that its life will be shortened. The following gives the results of tests made on hoisting cables taken from six different elevators:

TABLE IV—RECORD OF ⅜-IN. GOVERNOR CABLES

Elev. No.	Type	Date Installed	Date Removed	Mileage
1	6x19	6/15/13	10/ 1/14	3,800
1	6x19	10/ 1/14	10/19/19	27,323
1	6x19	10/19/19	11/ 4/21	9,402
1	8x19	11/ 4/21	.....	4,440
2	6x19	6/15/13	4/23/16	12,165
2	8x19	4/23/16	7/31/17	4,386*
2	8x19	7/31/17	11/ 5/22	15,800
2	8x19	5/11/22	.....	3,523
3	6x19	6/15/13	8/27/14	6,067
3	8x19	8/27/14	9/30/16	10,511
3	8x19	9/30/16	11/ 5/21	23,383
3	8x19	11/ 5/21	.....	4,251
4	6x19	6/15/13	10/15/15	9,727
4	6x19	10/15/15	10/ 8/17	7,187*
4	8x19	10/ 8/17	.....	19,387
5	6x19	4/15/13	10/11/15	20,825
5	8x19	10/11/15	10/13/19	32,399
5	6x19	10/13/19	7/ 4/20	6,030
5	8x19	7/ 4/20	.....	17,888
6	6x19	4/10/13	4/ 2/15	19,048
6	8x19	4/ 2/15	10/23/16	5,559
6	8x19	10/23/16	10/13/19	35,629
6	6x19	10/13/19	11/13/21	16,867
6	8x19	11/13/21	10/ 1/22	17,078
6	8x19	10/ 1/22	.....	739
7	6x19	6/ 1/13	8/ 7/14	11,845
7	8x19	8/ 7/14	10/16/15	13,438
7	8x19	10/16/15	12/24/16	11,972
7	8x19	12/24/16	10/20/19	25,408
7	6x19	10/20/19	7/24/21	14,177
7	8x19	7/24/21	.....	11,336
8	6x19	5/ 1/13	4/ 2/14	9,562
8	8x19	4/ 2/14	8/24/16	25,869
8	8x19	8/24/16	10/19/19	31,681
8	6x19	10/19/19	5/29/21	14,941
8	8x19	5/29/21	.....	13,323
9	6x19	6/15/13	8/14/14	4,693
†9	8x19	8/14/14	11/ 4/21	28,907
9	8x19	11/ 4/21	.....	3,968
10	6x19	6/15/13	8/21/15	11,035
10	8x19	8/21/15	10/19/19	20,757
10	6x19	10/19/19	10/26/21	7,905
10	8x19	10/26/21	.....	4,277
11	6x19	6/15/13	5/ 4/14	†4,861
11	6x19	5/ 4/14	8/21/15	7,014
11	8x19	8/21/15	8/24/16	5,304
11	8x19	8/24/16	7/24/21	22,907
11	8x19	7/24/21	.....	5,475
12	6x19	6/15/13	10/15/15	12,135
12	8x19	10/15/15	12/ 4/15	695*
12	8x19	12/ 4/15	11/ 4/21	27,358
12	8x10	11/ 4/21	.....	4,423

* Indicates cables cut by safety device. Sheave diameter, 16 in. Cables are bent twice in each single trip. Date of last reading, Nov. 1, 1922. All cables are iron except one marked †, which is mild steel.

Elevator No. 2

Elevator runs from the sub-basement to the 17th floor and return.

Travels 262 ft. 2 in.

Approximate length of cable, 316 ft.

Speed of car, 550 ft. per minute.

11.20 round trips per car mile.

Machinery: Traction gearless, 1-1 type, driven by 34-hp. motor. Motor sheave is 34 in. diameter, secondary sheave 34 in., deflection 10 inches.

Travel in handling passengers, averages from 1¾ to 2 min. per round trip.

Car capacity, 3,000 lb., 15 persons.

Car size, 4 ft. 8 in. wide, 6 ft. 3 in. long, 7 ft. 7 in. high.

Car weights, 1,400 lb. cage; 3,100 lb. beams, safety, etc.; total 4,500 lb.

Hoisting cables 6⅝ in.

Cables are bent eight times per single trip, or sixteen times per round trip. These cables are 6x19 iron with a hemp rope center, were placed in service July 31, 1917, and removed Feb. 28, 1922; service 4 yrs., 6 mo., 28 days, with a mileage of 18,603.87.

To determine the wear on the cables and the possible vitality left in them, six feet was cut from the center of the worst appearing cable of the six on the car. Three feet of this sample was cut off and taken apart to determine the number of broken wires therein and the other three feet tested at the University of Cincinnati to determine its breaking strength. Before the cables were cut they were wrapped with friction tape on each side of the cut to prevent unraveling. The cables had six strands as indicated below with nineteen wires in each:

Strand No. 1—1 of 19 wires was broken in	13	places,	18 wires O.K.
Strand No. 2—1 of 19 wires was broken in	5	places,	18 wires O.K.
Strand No. 3—1 of 19 wires was broken in	8	places,	18 wires O.K.
Strand No. 4—0 of 19 wires was broken in	0	places,	19 wires O.K.
Strand No. 5—1 of 19 wires was broken in	4	places,	18 wires O.K.
Strand No. 6—1 of 19 wires was broken in	1	place,	18 wires O.K.
	5		114
	31		109

The crystallization test showed that the inner wires would break after bending back and forth, while holding the wire between the thumb and fingers, until the ends almost met on an average of twelve times and the outer or broken wires would break on bending on an average of nineteen times.

Construction of Cables: The strands are built with one center wire having six wires around it and twelve wires around the seven. All wires are of the same diameter. The five broken were all outside wires and the balance of 109 were found in good condition. None of the outside wires were broken inside of the lay of the strand, but were broken on the outside lay of the cable. The 114 wires showed a total average of wear on all wires of 11 per cent. The wear on the cables was determined by using a micrometer on the individual wires and their loss due to wear noted. The three feet sent to the University of Cincinnati showed on test a breaking strength of 11,000 lb. The rating of this cable by the manufacturer was 1.2 tons (2,400 lb.) working load and 6 tons (12,000 lb.) breaking load.

The nut end of the sockets or shackles which are fastened to the crosshead of the car, are free to turn if the cables become slack. The counterweight fastenings are the same as those for the car.

Elevator No. 3

Other than the following the test data for this machine are the same as for elevator No. 2:

Elevator runs from the basement to the 17th floor and return.

Travels 235 ft. 8 in.

Approximate length of cable, 308 ft.

Cables placed Aug. 13, 1918, removed Feb. 27, 1922, service 3 years, seven months, 14 days, with a mileage of 16,113. The section of cable taken apart showed the following conditions:

Strand No. 1—1 of 19 wires was broken in	3	places,	18 wires O.K.
Strand No. 2—1 of 19 wires was broken in	1	place,	18 wires O.K.
Strand No. 3—1 of 19 wires was broken in	1	place,	18 wires O.K.
Strand No. 4—1 of 19 wires was broken in	9	places,	18 wires O.K.
Strand No. 5—1 of 19 wires was broken in	6	places,	18 wires O.K.
Strand No. 6—1 of 19 wires was broken in	5	places,	18 wires O.K.
	6		114
	25		108

The crystallization test showed that the inner wires would break after bending back and forth until the ends almost met on an average of eight times and the outer or broken wires would break on bending on an average

of ten times. The six wires broken were all outside ones, and the rest, or 108 wires, were found in good condition. None of the outside wires were broken inside of the lay of the strand but were broken on the outside, lay of the cable. The 114 wires showed a total average wear of 7.7 per cent. The three feet sent to the University of Cincinnati showed by test to break at 11,720 pounds.

Elevator No. 4

Other than the following the test data for this machine are the same as for Elevator No. 2:

Elevator runs same as No. 3.

Cables placed Oct. 8, 1917, removed March 13, 1922, service 4 years, 5 months, 5 days, with a mileage of 16,383.57. The section taken apart showed the following conditions:

Strand No. 1—1 of 19 wires was broken in 29 places, 18 wires O.K.			
Strand No. 2—1 of 19 wires was broken in 22 places, 18 wires O.K.			
Strand No. 3—1 of 19 wires was broken in 29 places, 18 wires O.K.			
Strand No. 4—1 of 19 wires was broken in 35 places, 18 wires O.K.			
Strand No. 5—1 of 19 wires was broken in 31 places, 18 wires O.K.			
Strand No. 6—1 of 19 wires was broken in 22 places, 18 wires O.K.			
6	114	168	108

The crystallization test showed that the inner wires would break after bending back and forth until the ends almost met on an average of seven times and the outer or broken wires would break on bending on an average of seven times. The six wires broken were all outside wires and the rest, or 108 wires, were found in good condition. None of the outside wires were broken inside of the lay of the strand but were broken on the outside lay of the cable. The original 114 wires showed a total average wear of 10 per cent. The three feet sent to the University of Cincinnati showed by test to break at 10,190 pounds.

Elevator No. 6

Elevator runs from the basement to the 28th floor and return.

Travels 390 ft. 8 in.

Approximate length of cable, 442 ft.

Speed of car, 750 ft. per minute.

6.75 round trips per car-mile.

Machinery: Traction gearless, 1-1 type, driven by 42-hp. motor. Motor sheave is 36 in. diameter; secondary sheave 36 in., deflection 10 inches.

Travel in service handling passengers averages from 3 to 3½ min. per round trip.

Car and load same as No. 2.

Hoisting cables, 6-⅝ in.

Cables are bent eight times per single trip or sixteen times per round trip, and are 6x19 iron, placed Oct. 30, 1917, removed March 29, 1922, service 4 years, 4 months, 28 days, with a mileage of 37,452.45. A test was made on a section of the worst cable of the six as for No. 2. The section of cable taken apart showed the following conditions:

Strand No. 1—12 of 19 wires were broken in 120 places, 7 wires O.K.			
Strand No. 2—12 of 19 wires were broken in 41 places, 7 wires O.K.			
Strand No. 3—12 of 19 wires were broken in 18 places, 7 wires O.K.			
Strand No. 4—12 of 19 wires were broken in 13 places, 7 wires O.K.			
Strand No. 5—12 of 19 wires were broken in 15 places, 7 wires O.K.			
Strand No. 6—12 of 19 wires were broken in 23 places, 7 wires O.K.			
72	114	230	12

The crystallization test showed that the inner wires would break after bending back and fourth until the ends almost met on an average of nine times and the outer or broken wires would break on bending on an average of six times. The construction of the cables was the same as for No. 2. The 72 wires broken were all outside ones and the remaining 42 were found in good condition. None of the outside wires were broken inside of the lay of the strand but were broken on the outside lay of the cable. The 114 wires showed a total average wear of 19.9 per cent. The three feet sent to the University of Cincinnati broke at the load of 10,950 lb. The rating of this cable by the manufacturer was 1.2 tons (2,400 lb.) working load and 6 tons (12,000 lb.) breaking load. The cable sockets or shackles are the same as on No. 2 machine.

Another test for crystallization on a short length taken from near the shackle on the car end of the cable and also a piece taken from near the shackle of the counterweight end of the cable, showed that it took an average of seventeen bends back and fourth until the ends almost met to break each of the nineteen wires in a strand. None of the wires was found broken in these strands.

Elevator No. 5

Except as noted in the following, test data for this machine are the same as for No. 6:

Elevator runs from the sub-basement to the 28th floor and return.

Travels 417 ft. 2 in.

Approximate length of cable, 478 ft.

Car capacity, 6,000 lb., 30 persons. (Equipped with a pawling device for handling of safes, etc.)

Car weights, 1,400 lb., cage; 3,100 lb. beams, safety, etc.; total 4,500 lb. (Pawling device 500 lb. additional.)

Cables placed July 4, 1920, removed March 27, 1922; service, 1 year, 8 months, 23 days, with a mileage of 21,506. The section of cable taken apart showed the following conditions:

Strand No. 1—1 of 19 wires was broken in 3 places, 18 wires O.K.			
Strand No. 2—1 of 19 wires was broken in 2 places, 18 wires O.K.			
Strand No. 3—1 of 19 wires was broken in 2 places, 18 wires O.K.			
Strand No. 4—0 of 19 wires was broken in 0 places, 19 wires O.K.			
Strand No. 5—1 of 19 wires was broken in 1 place, 18 wires O.K.			
Strand No. 6—1 of 19 wires was broken in 2 places, 18 wires O.K.			
5	114	10	109

The crystallization test showed that the inner wires would break after bending back and forth until the ends almost met on an average of twenty-one times and the outer or broken wires would break on bending on an average of twelve times. The five wires broken were all outside ones and the rest, or 109 wires, were found in good condition. None of the outside wires were broken inside of the lay of the strand but were broken on the outside lay of the cable. The original 114 wires showed a total average of wear on all wires of 12 per cent. The three feet tested broke at 12,400 pounds.

Elevator No. 8

Except as noted in the following, test data for this machine are the same as for No. 6:

Iron cables were placed March 12, 1920, and removed May 25, 1922, service 2 years, 2 months and 13 days, with a mileage of 20,464.76. The section of cable taken apart showed the following conditions:

Strand No. 1—2 of 19 wires were broken in 1 place, 17 wires O.K.			
Strand No. 2—1 of 19 wires was broken in 1 place, 18 wires O.K.			
Strand No. 3—5 of 19 wires were broken in 1 place, 14 wires O.K.			
Strand No. 4—8 of 19 wires were broken in 1 place, 11 wires O.K.			
Strand No. 5—1 of 19 wires was broken in 1 place, 18 wires O.K.			
Strand No. 6—3 of 19 wires were broken in 1 place, 17 wires O.K.			
20	114	6	94

The 20 wires broken were all outside ones and the remaining 94 were found in good condition. None of the outside wires were broken inside of the lay of the strand, but were broken on the outside lay of the cable. The 114 wires showed a total average wear on all wires of 21.4 per cent loss. The three feet tested broke at 10,940 pounds.

The Bayer Revolving-Element Soot Blower

Following some fourteen years of progressive experience with soot blowers, the Bayer Company, has developed a revolving-element soot blower in which are incorporated several new features. Referring to the illustration, the general construction of the blower will be readily understood. The interior steam element is securely locked in a central position within the outer or sectional metal air tube, so that both the interior steam element and the outer sectional air tube revolve as one element.

The inner steam element is insulated from the high furnace temperatures by a circulation of air between it and the outer sectional tube, which is also kept at a reasonable temperature due to the cooling effect of the circulating air.

The outer air tube is made of monel metal for high-temperature installations and of charcoal iron for medium temperatures. It is joined together by means of expansion sleeves to allow for expansion and contraction. The steam nozzles are also made of monel metal and to take care of expansion, ample space is provided for each nozzle where it projects through the outer tube.

An additional feature is the valve-in-head construction of the blower. The steam valve is controlled by a cam and worm gear and automatically opens and closes at the proper points with the rotating of the element. It will be seen that the valve stem does not extend through a stuffing box. This gives a free-moving valve at all times and tends to insure tight seating.

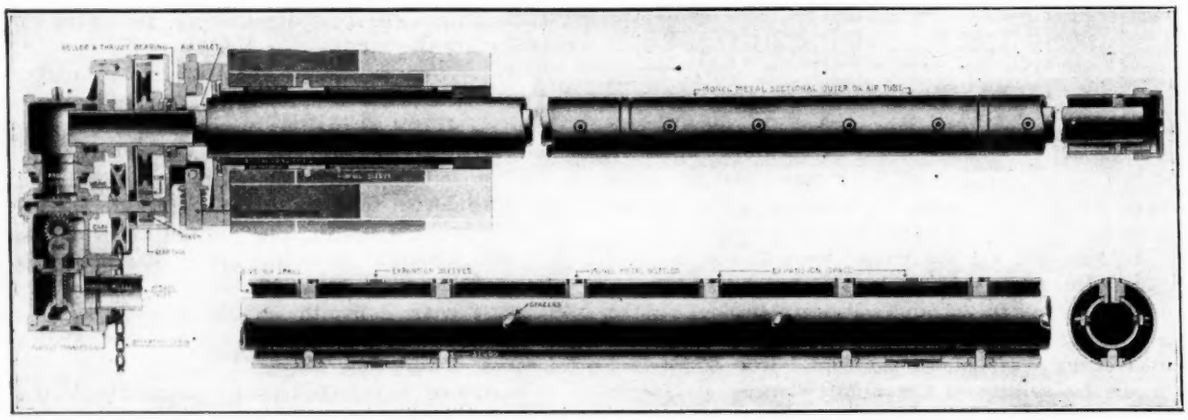
To get at the valve mechanism it is not necessary to break any pipe connections. A cap at the bottom of the blower head gives access to the mechanism. The only two stuffing boxes used can be readily packed or repacked without disturbing any other part, and the valve is so located in the blower head that steam condensation or water cannot accumulate above it.

The elements can be rotated in either direction. The steam jets are blown within a predetermined arc, making it impossible to blow except where necessary. The working parts of the head are incased and protected from the grit and dust of the boiler room.

The operating head is (full floating) so mounted that it is free to expand or contract with changes in temperature and with the expansion and contraction of the boiler walls or the pipe lines, without putting any straining or binding effect on the operating mechanism of the blower.

The usual method of operating by means of a chain and sheave is employed. This in turn is connected to the element through a reduction gear, as shown in the illustration. By using a reduction gear the unit cannot be revolved too rapidly, thus permitting the steam jets to work most effectively on the surfaces to be cleaned during a sufficient period of time. This gear, together with the roller and thrust bearings on which the element is mounted, makes it easy to operate.

Each blower element as regularly furnished is equipped with a geared head but without the automatic valve. It embodies the same features of construction and is entirely incased, the only difference being the absence of the valve. An exclusive feature is the provision for making steam connections in a horizontal or in any other position desired for convenience, without changing the usual vertical position of the head.



THE STEAM ELEMENT IS LOCATED IN SECTIONAL AIR TUBE—OPERATING HEAD IS FULL FLOATING

Attention should be given to seeing that the carbon packing at the low-pressure end of the main turbine is in good condition and effectively sealed at all times, also that the atmospheric relief valve is well sealed. Care must be taken to see that all joints, valve-stem packing, etc., on the exhaust piping or connections leading to the steam space of the condenser are maintained tight. It is advisable to paint the joints at intervals with asphaltum paint, also the condenser shell and exhaust connection to the turbine, to insure closing up all pinholes or porous spots. In this connection a warning should be given against the too common practice of making connections to the condenser for the purpose of priming pumps, laboratory use, etc. This practice is greatly to be deplored when high vacuums are desired since it gives many more joints and valves to leak and increases the difficulty of maintaining a tight system.

When a motor-driven induced-draft fan is employed for supplying draft for a number of boilers, the motor should be protected by an overload relay to prevent an overload being thrown on it by the accidental opening of a damper on a dead boiler at a time when the motor may be operating at full capacity.

The Unit Heater

A Common-Sense Discussion of the Use of the Unit Heater for Warming Large Spaces

By CHARLES L. HUBBARD
Consulting Engineer, Boston, Mass.

THE necessity for rapid building construction during the World War led to the use of a form of heating equipment that has proved so satisfactory that it has come into general use in certain types of buildings. This is known as the "unit heater," or "portable blast heater," and is especially adapted to the warming of large open spaces such as are found in the modern industrial plant. One-story buildings having monitor or saw-tooth roofs lend themselves particularly well to this form of heating; also buildings of several stories where the floor space is not divided into smaller rooms.

A typical form of unit heater is shown in Fig. 1 and consists of a radiator made up of pipe coils or cast-iron sections, inclosed in a heavy sheet-iron casing and provided with a fan for passing the air through the heater. The fan may be either of the propeller or centrifugal type, and driven by an electric motor or steam turbine, or belted to the lineshafting. In the illustration shown, the air is drawn in at the floor level, forced through the heater and delivered horizontally in two directions. In Fig. 2 the action is reversed, the air being drawn in at the top and delivered at the floor level. Both these units are supported by a base resting on the floor. Another arrangement is illustrated in Fig. 3, in which case the apparatus is hung from the overhead construction, thus leaving the floor space clear of all obstruction.

These illustrate, in a general way, the principles involved in the design of heaters employed in rooms and buildings used for industrial purposes where appearance and ventilation are of secondary importance and large heating capacity is required. In the case of offices, drafting rooms, etc., where it is desired to combine ventilation with heating, use is made of a line of equipment brought out by various concerns. An example of this kind of equipment is shown in Fig. 4.

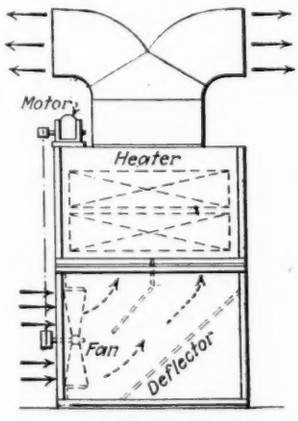


FIG. 1—UNIT HEATER WITH ELEVATED DISCHARGE

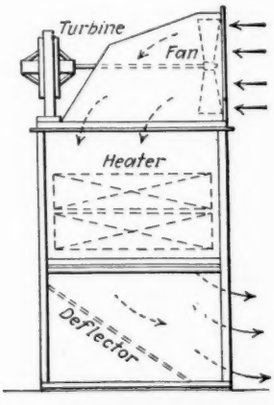


FIG. 2—UNIT HEATER WITH FLOOR DISCHARGE

These units consist of heater, fan and motor, inclosed in a case or cabinet and usually placed in front of a window. Fresh outside air is admitted either through a special opening in the wall, as shown in the cut, or by raising the lower sash. A mixing damper, either hand or automatically controlled, is provided for varying the temperature of the air, and also a recirculating damper for night use or for such other times as it may be desired to furnish heat without regard to ventilation. A pan of water at the bottom of the casing serves as a dust collector and to some extent as a humidifier for moistening the air.

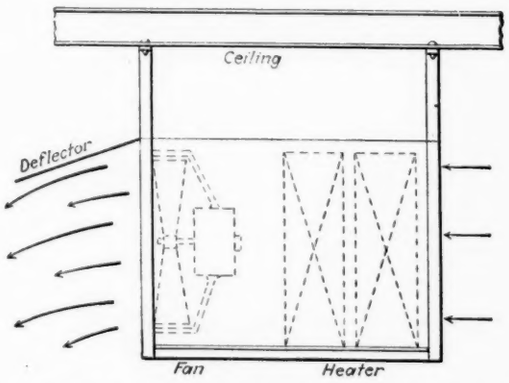


FIG. 3—UNIT HEATER SUSPENDED FROM OVERHEAD CONSTRUCTION

Comparison With Other Systems

As ordinarily used, the unit heater is a device for warming only, although connections can easily be made for drawing the air supply, or any portion of it, from out of doors if so desired.

In the type of building for which it is usually employed, the cubical space is large compared with the number of occupants, and sufficient fresh air for ventilation purposes finds its way in by leakage. When considered as a heating device only, the unit system should be compared as to cost of installation and operation, and general results obtained, with systems of direct radiation. Concerning cost, it may be stated that in the average building it is cheaper to install than direct radiation, the case of a large plant being reported where the estimate was twenty-five thousand dollars less than the proposals for direct heating. The size of plant and other local conditions will, of course, vary in each individual case, so that no definite figures for general use can be given for purposes of comparison.

The saving in unit heating is due principally to the higher efficiency of the radiating surface, caused by the greater velocity of the air passing over it, so that on an average only about one-sixth as much surface is required. Again, the whole outfit is factory built, which results in a considerable saving in cost of labor. A unit heater containing 500 or 600 sq.ft. of radiating surface has but one steam and return connection, while the equivalent 3,000 to 4,000 sq.ft. of direct radiation

would be divided into a considerable number of coils or units, each requiring its own connections, valves, etc., and branch runs of varying length.

As to cost of operation a given building requires a definite number of heat units for warming it under given conditions, regardless of the method of supplying them. One method, however, may supply the heat more effectively and with less waste than another, and this point should be considered in connection with unit blast heating.

Referring to Fig. 5, *A* and *B* show the usual locations of the heating surface (solid-black rectangles) in a monitor-roof building warmed by direct radiation, and the arrows indicate the approximate direction of the air currents produced in each case. When the coils are hung overhead, as in *A*, the greater part of the heated air rises directly into the monitor while a portion flows along the underside of the main roof. Becoming cooled by contact, it gradually falls and, meeting the currents that are rising to fill the partial vacuum produced by the heating coil, mixes with them and again rises to complete the circuit. It is evident from the diagram,

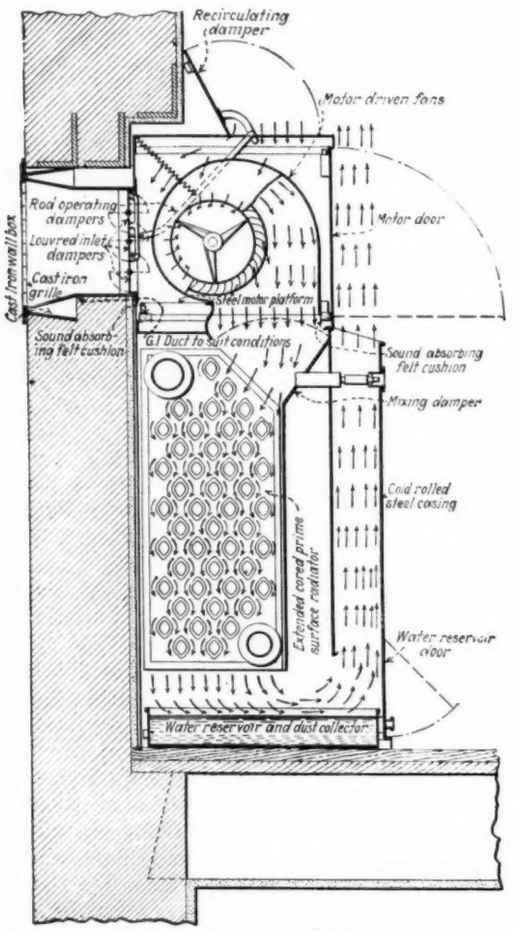


FIG. 4—UNIT HEATER FOR OFFICES, DRAFTING ROOMS, ETC.

and also borne out in practice, that the greater part of the heat remains in the upper part of the building and produces but a limited warming effect in the occupied zone near the floor, where most needed. Furthermore, the excessively high temperature of the air in contact with the roof increases the rate of heat transmission through it, and so results in a decided loss, for which additional fuel must be provided.

In the arrangement shown at *B*, with the coils placed under the windows, the path of the air currents is much the same, but in a reverse direction. The heated air from the coils first rises, flows toward the center of the building in contact with the cold roof, and then as it cools, falls toward the floor and mixes with the current which is being drawn toward the hot coil to

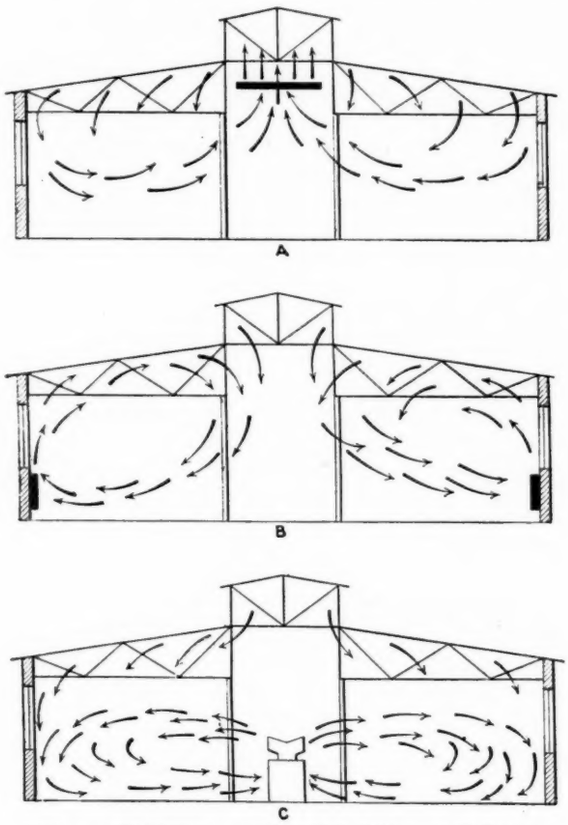


FIG. 5—HEATING A MONITOR-ROOF BUILDING—*A* and *B*, direct radiation; *C*, unit heater

continue the circulation. The net result in this case is much the same as in *A;* that is, the hottest air is in contact with the roof, while the occupied zone near the floor receives but a comparatively small part of the warm current, being out of its direct path.

The arrangements shown in *A* and *B* are frequently combined, and while this results in a more general diffusion of the air currents, due to their opposite directions, the tendency is for the warm air to rise directly to the upper part of the building, leaving the lower part comparatively cold, as before.

When a unit heater is employed, discharging the warm air horizontally toward the outer walls at a height of 7 to 10 ft., the path of the currents is similar to that indicated by the arrows in *C* (Fig. 5). The tendency of the warm air to rise is checked by the cooler air settling from above, and as the mixture is thus lowered in temperature, it gradually falls during its outward movement toward the walls. As the return air enters the heater casing at a low level, the passage toward it is along the floor.

With this arrangement the entire air circuit, out and back, is kept in a zone approximately eight to twelve feet in height, regardless of the height of the room, the tendency to rise being largely overcome by the slow downward movement of the cooler air from above. In

this way the warm air is evenly diffused throughout the lower part of the room, where it is needed, while the upper part remains comparatively cool, thus reducing the waste of heat by transmission through the roof. While this works out nicely in theory, practical results confirm it, a condition not always true in heating problems.

When a heater of the general type shown in Fig. 2 is used, the results are much the same as shown in *C*, Fig. 5, except that the direction of the current is reversed.

Types of Heaters

Although both of the forms of heaters shown in Figs. 1 and 2 are in common use, the first of these represents the more common type. For a good diffusion it is desirable to discharge the air at a fairly high velocity so as to reach the outer walls without too much opportunity for the air to rise. It is evidently desirable to keep currents having a high velocity above the heads of the occupants. On its return to the heater, the air has spread out over a much larger area, and its velocity is so reduced as to be practically imperceptible as it moves through the occupied zone. If the air were driven along the floor at a high velocity it would not only produce uncomfortable draft, but also pick up dust and litter in shops where certain mechanical processes were carried on, as in woodworking, the manufacture of shoes, etc.

The bottom-discharge type is usually confined to the small and medium sizes and employed where the conditions noted would not be objectionable. It is frequently used for warming spaces around entrances where outside doors are often opened and also in rooms containing an excess of moisture, where it is desired to deliver large volumes of warm dry air near the floor. In the latter case the supply should, in general, be drawn from some other room or building where the air is comparatively dry, or else taken from out of doors.

Another application of this type of unit is found where it is desirable to draw the air supply from the upper part of the room, in which case the heater is raised on legs or supports which bring the discharge seven or eight feet from the floor and the inlet nearly twice that height.

The overhead type (Fig. 3), when given a proper elevation, produces much the same result as that shown in Fig. 1, except for the fact that the air enters at a higher elevation. This method of support is used only where floor space cannot well be spared for the standard designs. The particular unit illustrated in Fig. 3. is also made with floor supports. The adjustable deflector used with this heater makes it possible to place the air where most needed and is made use of in two ways. One of these is to determine by trial the best angle to employ and then to fix the deflector permanently in that position, and the other is to deflect the air quite sharply downward when first warming up in the morning and then to raise the blade gradually so that it reaches a horizontal position when normal conditions have been attained.

Constructional Details

The constructional details are not, in general, of interest to the operating engineer or manager of a plant, but he should be familiar with certain features that have a decided bearing on the selection and use of apparatus of this kind.

The majority of the unit heaters on the market make use of the propeller or disk fan, although some manufacturers employ the squirrel-cage or multi-vane type. Either gives excellent results in this class of work.

As the resistance to be operated against is low, owing to the open pattern of heater and the absence of distributing ducts, the propeller fan gives a good degree of efficiency, requires but little power to operate and is low in first cost. The objections to its use in the ordinary systems of hot-blast heating do not hold in the present case. When high-pressure steam is available, the turbine makes a good form of drive, as it runs at a speed suitable for direct connection with the fan, and furthermore, the exhaust can be used in a portion of the heater, thus reducing the cost of power to practically nothing. If it is desired to utilize exhaust steam from the main engines, or if electric power is purchased and low-pressure heating boilers are employed, an electric motor is the most convenient drive. Sometimes the fan is belted to a near-by line of shafting, but an independent drive is always preferable, as it is usually necessary to start the apparatus and warm up the building before the lineshafting is in operation.

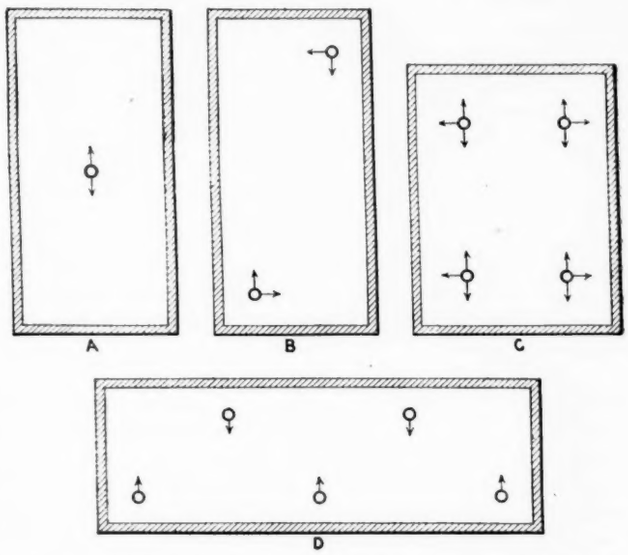


FIG. 6—TYPICAL ARRANGEMENTS OF UNIT HEATERS IN LARGE ROOMS

Most of the heaters are constructed of wrought-iron pipe or made up of "Vento" cast-iron sections. Pipe heaters are in some cases made up with cast-iron headers, while in others return-bend fittings are employed or the pipes are welded together without the use of fittings.

The result to be obtained in any case is a heater of low resistance to air flow, which at the same time breaks up the air currents and gives a high efficiency for a given amount of surface. The casings are built of heavy sheet iron or steel upon a substantial frame of structural steel.

Comparison with Duct Systems

The unit heater is not intended to replace the regular system of hot-blast heating with distributing ducts, except in the special type of building to which it is particularly adapted. This, as previously stated, is the modern industrial building made up of large interior spaces. When the building is divided into a number of

separate rooms, a single outfit or central plant, located in the basement and connecting with the different rooms by means of duct and flues, is necessary in most cases, and the unit heater would hardly be considered in work of this kind.

In comparing the two systems, when applied to large interiors, we may say that the duct system delivers the warm air at a comparatively high velocity in a large number of places. The results are, to a considerable extent, local in the vicinity of the points of discharge, and more or less churning of the air and draftiness is produced. The unit heater, when properly designed and placed, tends to keep the whole body of air filling the room, in slow motion, without drafts, except at an elevation above the heads of the occupants and in the vicinity of the discharge outlets.

Owing to the absence of ducts the cost of both installation and operation is less, and there is also no interference with shafts, belts or lighting equipment. The early objection, that the use of smaller and less efficient fans would increase the power requirements, has not held true, and the actual power consumed in the average plant is considerably less than with a duct system. This is due to the elimination of the frictional resistance of the ducts and to improvements in fan design which make it possible to secure a good efficiency with the sizes and types used for this class of work.

The catalog of a well-known make of unit heaters states that the propeller fan designed for this particular work has an efficiency equal to most centrifugal fans up to a pressure of ½-in. water column, while the cost of construction is but a fraction of that for a centrifugal fan of the same capacity. It is also stated in the same catalog that the fan used with one of this company's unit heaters will deliver 15,000 cu.ft. of air per minute with an input of 1.1 b.hp. The same concern rates its centrifugal fan, delivering the same quantity of air through a duct system under the resistance ordinarily found in factory heating, at 7 b.hp. This item alone, in case of a large plant, is well worth considering in buildings to which the unit heater is adapted.

Engineering Data

When making definite plans for the heating of any given building by the unit system, it is best to refer all matters pertaining to size and number of units, location, etc., to the makers of the particular apparatus it is proposed to use. Conditions vary considerably, even in buildings of the same size, and different makes of equipment have peculiarities that must be taken into account. For this reason manufacturers of unit heaters prefer not to give out much data for general use, but to make a study of each individual case before recommending the size and general arrangement of their equipment. There is available, however, some general information which is useful in making approximations and in blocking out preliminary work.

Standard unit heaters are made in various capacities ranging from 200 to 20,000 cu.ft. of air per minute. The temperature of the air returned to the heater will average from 60 to 65 deg., although it may be somewhat lower in some cases. It has been found by experience that if the air is discharged into the room at a temperature much in excess of 135 deg., it will not diffuse readily and stratification will result. For the best results it is usually advisable to keep the maximum temperature between 110 and 130 deg. If we assume a heating range of 60 deg. to 120 deg., then $\frac{120-60}{55} = 1.1$ B.t.u.[1] will be given out by each cubic foot of air in cooling from 120 deg. to 60 deg. For an inside temperature of 65 to 70 deg. it is safe to say that under average conditions one cubic foot of air should be passed through the heater for each B.t.u. lost from the building by transmission and leakage.

The velocity of discharge into the room varies in different makes of heaters and ordinarily runs from 1,000 to 2,000 ft. or more per minute. The higher velocities must be kept well above the heads of the occupants and are used for extending the range of the heater and in giving a slow general movement to the entire air body of the room, as previously stated.

The accompanying table giving data relating to a number of standard makes of equipment has been collected from various sources.

DATA RELATING TO STANDARD MAKES OF UNIT HEATERS

Heater	Cu.Ft. of Air per Min.	Steam Pressure Lb. Gage	Initial Air Temp., Deg.	Final Air Temp., Deg.	B.t.u. per Hour
A	2,000	5	60	130	121,000
B	5,000	5	60	130	336,000
C	10,000	5	65	115	528,000
D	15,000	5	65	115	749,000
E	1,925	60	60	165	215,000
F	2,070	100	60	167	236,000

As regards the floor space that may be warmed by a single unit, there seems to be a wide variation, depending on the capacity of the heater, the number of discharge outlets, the type of building and the purpose for which it is used. In a number of actual installations investigated, the floor area per unit varied from 2,000 to 10,000 square feet.

The location of the units is an important matter and should receive careful attention. There seems to be no standard arrangement and much seems to depend upon local conditions. The diagrams shown in Fig. 6 embody the general methods in a number of installations. The object sought in all cases is a thorough diffusion of warm air and the avoidance of cold drafts and unheated spaces.

Owing to the fact that all fuel oil contains a certain amount of base sediment and dirt, strainers are an essential part of every installation. In good practice it is customary to install a pair of such on the suction side of the pump, to remove larger particles of foreign matter and serve as protection for the pump chambers, particularly if a crude oil is to be fired. Duplicate strainers are installed on the discharge side as well, after the oil has passed through the heater, to remove all final particles of dirt, shreds of packing or scales, etc., and prevent such from passing to the burners to score or clog them. Suction strainers may or may not be a requirement, depending on the engineer's opinion of the quality of his oil and the guarantee he receives at its delivery, or a desire to reduce first expense of the installation. Discharge strainers, however, should always be installed.

I succeeded in teaching a little darkey the theory of combustion and CO_2 by talking air to him, and to this day he doesn't know there is such a thing as CO_2. He is now head fireman at that plant and has cut the coal consumption from 30 tons a day to 22, although production has increased 6 per cent. Sam knows that the less red ink there is on that chart, the less coal he will have to burn.—*J. T. Beard, Industrial Management.*

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[1] One B.t.u. will raise the temperature of one cubic foot of air 55 degrees.

Coal Storage at Detroit Water-Works

In the accompanying illustration is shown the complete system of storage and coal handling adopted by the Detroit water-works, to insure an adequate supply the year around, as delivery is by water, and to take advantage of the reasonable prices prevailing throughout the summer months. A 25,000-ton shed was erected to receive the coal and a canal dug to the Detroit River, which is some 2,000 ft. distant, to give passage for the barges.

The coal-handling and storage installation, completed in 1922, was designed to crush and store coal at the rate of 100 tons an hour and to supply it intermittently to any one of twelve 4,000-sq.ft. horizontal water-tube boilers equipped with underfeed stokers. The sources of supply are the Toledo pool of Ohio and Pennsylvania run-of-mine bituminous coal. Barges are docked in the department's canal and unloaded by clamshell buckets and crane into a hopper with a reciprocating feeder delivering to a 30-in. double-roll crusher. The crushing equipment and the lower end of a 24-in. inclined belt conveyor, together with the motors and interlocking control, are housed in a brick tower which supports the lower end of a reinforced-concrete bridge inclosing the belt conveyor. On its journey to the storage building the coal is weighed as the belt passes over a Merrick integrating weightometer.

At the entrance to the storage building the inclined conveyor delivers to a 24-in. horizontal belt which distributes the coal along the south wall by means of an automatic self-propelling and reversing tripper. The building, which is 320 ft. long and 180 ft. wide, is divided by a central crosswall. It is constructed with reinforced-concrete retaining walls for a height of 20 ft., and from the top of the concrete up to the parapet ordinary brick curtain-wall construction is employed. The entire roof area is made up of reinforced-

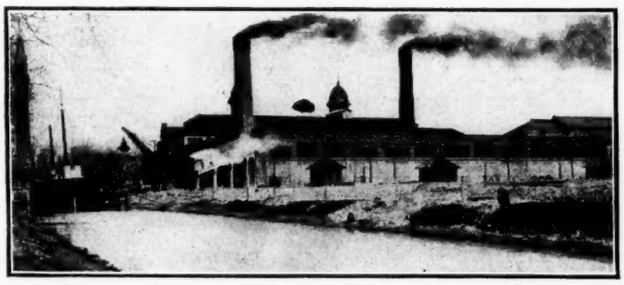


FIG. 1—LONG LOW COAL STORAGE BUILDING OF 25,000 TONS CAPACITY WITH TWO UNITS OF BOILER HOUSE IN REAR

concrete slabs of 10-ft. span supported on a system of Pratt and girder trusses. Only two concrete-steel columns in each half of the building obstruct the clear area.

Coal is stored to a depth of 20 ft. and is leveled up or reclaimed by means of drag scrapers of 1,000 lb. capacity. A complete scraper system with a power unit is provided in each half of the building. One may be used for leveling up the coal as it is delivered from the 24-in. belt, and the other for reclaiming the daily supply to hoppers installed centrally in the north side of the building. From the hoppers, which are inclosed in a concrete pit, feeders deliver the coal into the boot of a bucket elevator discharging into a 175-ton cylindrical steel bucket 19 ft. in diameter, located centrally between the east and west boiler-house units and directly over the line of travel of a 1-ton motor-driven weigh-larry feeding the stoker hoppers.

It should be explained that the boiler house is in effect two distinct installations, each with its own chimney, boilers, breeching, feed-water heaters and pumps. The boilers are grouped in batteries of three on either

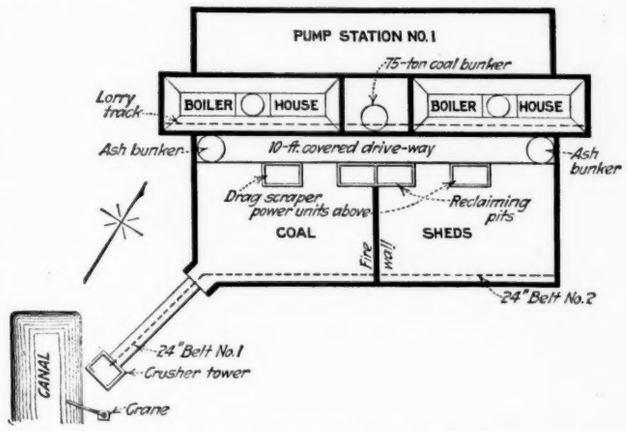


FIG. 2—LAYOUT OF COAL- AND ASH-HANDLING EQUIPMENT

side of each of the two 150-ft. chimneys. The units of the boiler house are separated by two fire walls with a shop space of 20 ft. intervening.

For either unit the coal-and-ash-handling systems have been kept separate, so that failure of one might not interfere with the operation of the other. In either boiler house the ashes are drawn by hand from the stoker ashpits into 18-cu.ft. industrial cars moved by one man along a 24-in. gage track to the 20-cu.ft. bucket of a skip hoist, provided with push-button control. Ashes are elevated and delivered into a 2,500-cu.ft. ash bunker 14 ft. in diameter. Through a two-way balanced duplex gate in the bottom cone of the bunker, about nine feet from the ground level, the ashes are discharged into motor trucks.

The installation is said to have proved satisfactory in every way. It is of interest that of the 20,000 tons of coal weighed in over the weightometer during a certain period of last year, the coal weighed out on the larry scale checked this figure by less than 50 tons, the discrepancy, no doubt, being due largely to evaporation of the moisture.

Under-water storage is not practicable at Detroit because of the cold winters. After various schemes for combating possible fires from spontaneous combustion were considered, it was decided that barricading the two doors giving access to the storage building and flooding the entire building with water to a depth of four or five feet would quench any fire that a trench cut through the affected area with a drag scraper would not control.

The coal-handling equipment was installed by the Guarantee Construction Co., of New York, and the ash-handling equipment by the Palmer Bee Co. of Detroit. The design and construction of the work was carried out under the general direction of George H. Fenkell, superintendent and general manager, and Theodore A. Leisen, consulting engineer.

Polyphase Transformer Connections

COMPARISON of the different three-phase connections of single-phase transformers, showing characteristics, advantages and disadvantages of connections commonly used.

BY R. F. GOODING
Electrical Engineer, Charles B. Hawley & Co., Washington, D. C.

IN CONSIDERING the various polyphase transformer connections, in order to determine which one is best suited to his particular needs, the engineer should be able to compare them intelligently, with regard to the inherent merits or demerits of each scheme, the kilovolt-ampere capacity required for each, the regulation of the individual units, etc. It is the purpose of this article to discuss briefly the more common forms of three-phase transformation and to show what recommendations each scheme has and what its inherent defects are. Such connections as the delta to zig-zag, etc., will not be treated here, as they are more or less special and rarely met in ordinary practice.

The order in which the different groupings will be considered is as follows:

1. The best known and most widely used transformer connection is the delta to delta. This scheme is still used on most of the distribution systems, networks, etc., in the country, although of late there has been a marked increase in the adoption of the three-phase four-wire system. The usual distributing voltage is 2,300 high tension to 110, 220, or 440 volts low tension, as the case may be. When distributing at 2,300 volts, or with any delta to delta connection, it is customary to use delta to delta at the power-station end also.

In this scheme any three transformers of similar characteristics can be used, as the voltage stress on the different units is the same as when operating single-phase. This is not true of a star connection (star to star or star to delta), as transformers not designed for star connection are subjected to unusual and often destructive voltage stresses when so connected.

As indicated in Fig. 1, the line voltage E is the same as the normal voltage rating of each unit, and the line current I, being a combination of that from two units, is $\sqrt{3}$ (1.73) times the rated full-load current of one unit. Or, to put it another way, the voltage across each unit is line voltage, and the current in each unit is line current divided by 1.73. Since the voltage and current of each unit are in phase with each other, the transformers' internal power factor is unity, and they will contribute their full kva. rating to the bank, or more correctly, to the load. Hence, the ratio of kva. capacity to kva. transformed (or delivered) is unity. The regulation of the separate units in the delta to delta connection is the same as when operating single-phase. Also, with this connection there is no third harmonic voltage on the line, as the deltas circulate this magnetizing current and prevent its appearance on the line itself.

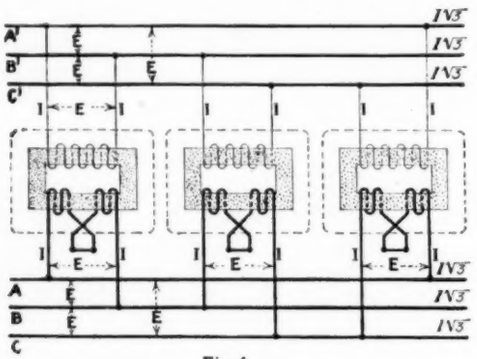


Fig. 1

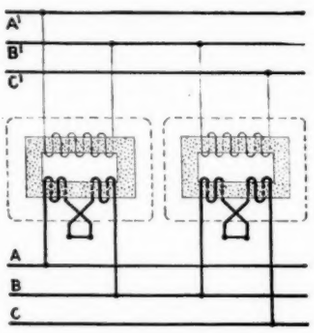


Fig. 2

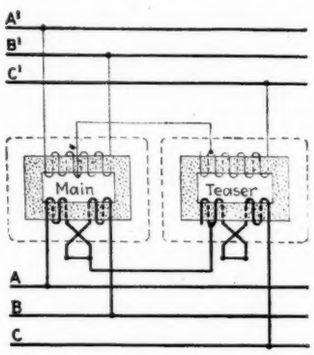


Fig. 3

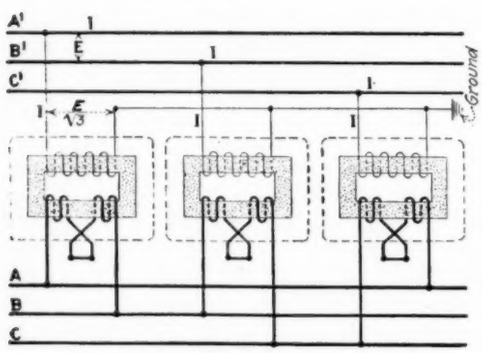


Fig. 4

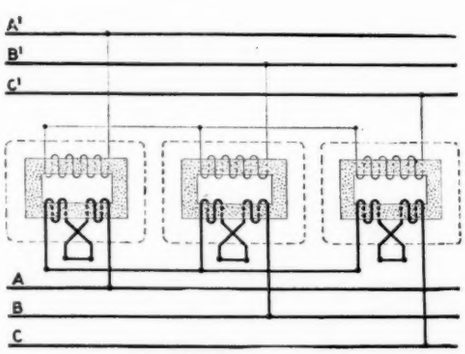


Fig. 5

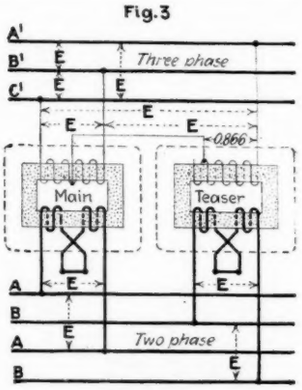


Fig. 6

FIGS. 1 TO 6—GROUPING OF SINGLE-PHASE TRANSFORMERS FOR 2- AND 3-PHASE CONNECTIONS
Fig. 1—Delta-to-delta connection. Fig. 2—Open-delta connection. Fig. 3—"T" connection. Fig. 4—Star-to-delta connection. Fig. 5—Star-to-star connection. Fig. 6—Three-phase to two-phase (Scott) connection.

A factor in favor of the delta to delta connection for distribution systems is that the ordinary distributing transformer can be built more cheaply for delta than for star connection. As the voltage increases this condition will not continue, in fact the opposite becomes true, and for high voltages the star-connected transformers will be found cheaper than the delta-connected. However, as popular as this connection is, like all others it has its disadvantages. The first is that there is no neutral available with the standard units, and this scheme, when used exclusively, does not provide a grounded neutral. For ordinary distribution this is not a serious drawback, as the average distribution system is not grounded. Transmission systems, as shown later, are usually grounded, and another transformer connection is used for them. Also, a small difference in the ratio, or impedance of the different units, will cause a circulating current and an unequal load distribution among the units.

A short-circuit in one of the units will cause a phase-to-phase, or power short-circuit, and when this short-circuit occurs on the load side of the bank, very heavy short-circuit stresses are introduced in all the windings. In case of a ground on one line the voltage strain on the two sound lines is raised to 1.73 times normal. This excess potential may puncture or destroy line insulators, and this fact is one of the causes of most high-voltage transmission systems being energized from star-connected transformers, with grounded neutrals.

Advantage of Delta-to-Delta Connection

One advantage of the delta to delta connection just discussed, is that disabling of one unit will not put the bank entirely out of service, as the faulty unit can be cut out and the two remaining units will operate in open delta, or "V," as shown in Fig. 2. With this scheme, the current and voltage in each unit are 30 deg. out of phase, resulting in an internal power factor of 86.6 per cent, and each transformer can deliver to the line only 86.6 per cent of its rated capacity. Therefore the ratio of kva. capacity to kva. transformed, or delivered, is 1 to $0.866 = 1.15$. Suppose then, in a bank of three 100-kva. transformers that one goes bad and the other two are run in open delta. This reduces the capacity of the bank from $3 \times 100 = 300$ kva. to $2 \times 100 \times 0.866 = 173.2$ kva. or 58 per cent of the original rating. If the original bank were running at full load, this would put an overload of 73 per cent on the two remaining units. As a matter of fact, comparatively few transformer banks on distribution systems run at full load for any length of time, and there are few instances when the open-delta will not tide over until the old unit is repaired or a new one obtained.

It is quite common practice with some operating companies to supply a new customer from open-delta connected transformers and when the load increases, to add the third unit and make a closed-delta or delta to delta system. Since the ratio of kva. capacity to kva. transformed equals 1.15, this is not an economical arrangement, and its use should be confined as a general thing to emergencies. This scheme is more susceptible to circulating currents than the delta-to-delta connection. The regulation of the separate units is different from the single-phase regulation, but its calculation is too complicated to be discussed here.

A scheme somewhat similar to the open delta is the "T" or "teaser" connection shown in Fig. 3. The main transformer must have the middle points of both windings brought out and the teaser have a capacity or voltage ratio, 86.6 per cent of the main unit. In practice it is customary to have them duplicates, using the 86 per cent voltage taps on the teaser. Some companies having both two-phase and three-phase systems buy transformers with 5 per cent and 10 per cent voltage taps on both the high- and low-tension sides, and have the middle points of both windings brought out. For Scott connection this gives essentially the correct ratios, while for three-phase to three-phase they often operate two units T-connected. With the "T" connection the neutral can be brought out and grounded. When using duplicate units for main and "teaser," the ratio of kva. capacity to kva. transformed equals 1.15, the same as for open delta.

With the "T" connection, however, the regulation is poor. As a general proposition this connection is not considered so satisfactory as the open delta, since it requires special transformers, which always cost more than standard units.

Delta-Star and Star-Delta Connections

For use on transmission lines of moderately high or high voltage the delta-star arrangement is used almost to the exclusion of the other systems. This statement is made with due deference to those who still prefer a delta-connected, ungrounded transmission system, rather than the star-connected grounded system, but the consensus of opinion now seems very much in favor of the grounded system. There is really no difference between the delta-star and the star-delta, and where one is used the other is usually found to be necessary. This is particularly so on transmission lines where the power-station transformers will be delta-star, and the substation, or receiving, transformers, star-delta. This scheme, as shown in Fig. 4, has several distinct advantages over the others, as follows:

(1) The neutral is stable and can be grounded, giving all the advantages inherent to a grounded system; (2) the delta side circulates whatever third harmonic magnetizing current there is and prevents its appearance on the line; (3) differences in ratio, or impedance, are to a large extent offset by a small magnetizing current circulating in the delta; (4) a single-phase short-circuit on the secondary lines will cause lower short-circuit stresses in a delta-star step-up bank than in a delta to delta bank; (5) a short-circuit in one leg of the star side does not affect the voltage on the delta side. With this connection the ratio of kva. capacity to kva. transformed is unity, and regulation of the various units is the same as when operating single phase.

Unlike the delta-delta, the delta-star cannot operate on two units in case one is disabled. If the bank is an important one, a spare unit must be provided. However, considering the merits and demerits of this scheme, there is found much more to commend than to condemn in it, and this connection, all things considered, is probably the most satisfactory of all the three-phase connections.

Star to Star Connection

The star to star connection, shown in Fig. 5 is not used very extensively because its neutral is unstable, making it unsuited for grounded systems. A short-circuit in one unit will not cause a power short as in the delta-to-delta bank, but will raise the voltage on the

other two units to 1.73 normal voltage, and thus cause an abnormal magnetizing current. The high-voltage star-to-star bank is cheaper to build than the similar delta-to-delta bank, and differences of ratio or impedance will not cause circulating currents as in the delta-delta.

Like the delta to star, the star to star cannot operate on two units, and a spare transformer should be provided. With this scheme, there may be a third-harmonic voltage on the line ranging anywhere from 3 to 50 per cent of normal, depending on the design of the transformer, and grounding the neutral will only increase this value.

Three-Phase to Two-Phase Connection

In the Scott connection for transforming from three to two-phase or vice-versa, only two units are used, as shown in Fig. 6. On the three-phase side one unit, the main, has its 50 per cent tap brought out, while the other, teaser, has only 86.6 per cent of the voltage rating of the main. In practice, the two units are usually duplicates, each having a 50 per cent and 86 per cent tap on the three-phase side.

Mention has already been made of the practice of some companies of providing 5, 10, and 50 per cent taps on both windings and using two units for three-phase to three-phase with "T" connection, or for Scott three-phase to two-phase. The windings on the two-phase side are electrically distinct and may be connected for either two-phase four-wire, or two-phase three-wire. For emergency operation, two standard transformers can be used, one having 50 per cent tap. This will not give a phase difference of exactly 120 deg., and if this bank is paralleled with a true three-phase bank it will cause considerable unbalancing of currents.

SUMMARY OF TRANSFORMER CONNECTIONS

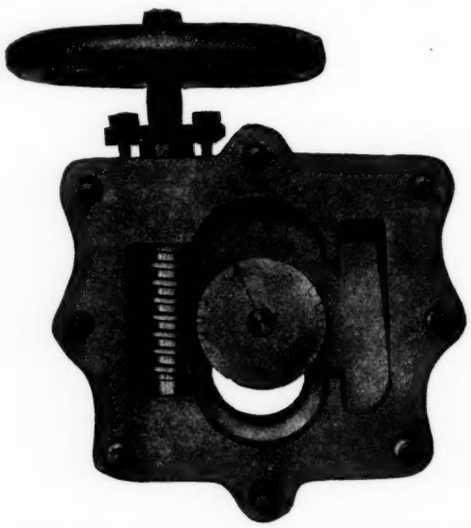
Connection	Figure Nos.	Number of Units	Kva. Cap. to Kva. Del.	Regulation	Suitable for Grounded System
Delta-Delta	1	3	1	Same as 1 phase	No
Open Delta	2	2	1.15	Poor	No
T	3	2	1.15	Poor	Yes
Delta-Star	4	3	1.	Same as 1 phase	Yes
Star-Star	5	3	1.	Same as 1 phase	Yes
Scott	6	2	1.15	Poor	Yes on 2 phase side

The principal application of the Scott connection is the interconnection of three-phase and two-phase systems. The regulation of the two units is the same as when operating "T" connected, and the ratio (using duplicate units) of transformer kva. to kva. transformed, or delivered, is 1.15. The table gives a summary of the points just brought out showing the salient characteristics of each connection.

Perolin "Double-Service" Blowoff Valve

A new type of straightway blowoff valve that automatically cleans and reseats itself and that can be turned end for end when one side is worn, has been put out by the Perolin Company of America, 122 South Michigan Ave., Chicago. As shown in the illustration, the valve consists of a central ring or body carrying a solid disk with gear teeth cut between its faces, an operating worm attached to the handwheel and on the other side of the disk a movable geared rack. Covers ground on the inner surface to form a seat and bolted to the body, carry the piping connections.

As the teeth of the disk are enmeshed with those of the worm and the rack, turning the handwheel revolves the disk, causing it to travel up or down on the rack with a combined turning and sliding motion. In its lowest position the disk covers the outlet. Revolving the handwheel to the right turns the disk in a clockwise direction, so that it travels up along the rack, uncovering the passage. When it has reached the upper limit, the passage is entirely clear. In the cut only part of the teeth on the disk are indicated. Further turning of the handwheel merely rotates the disk, throwing back the rack against its spring as each gear tooth passes the upper tooth of the rack. Reversing the direction of the handwheel lowers the disk. At the lower limit continued rotation of the handwheel rotates the disk as before, the spring pushing down the rack into mesh with the disk as each tooth passes.



COVER REMOVED TO SHOW WORKING PARTS

Owing to its construction, the valve cannot jam, the disk may be reground to its seat under pressure while in operation, and as either side can be used as inlet or outlet, the valve may be reversed if one side should become leaky by wear. In opening or closing, the valve is said to be slower than the lever-operated type but quicker than the usual screw-stem valve. In the 2-in. size twelve turns of the handwheel fully open or close it.

Steel Veneer

While firebrick of porous structure will withstand high temperatures, the high porosity often fails to combat the action of the gases. Preparations have been brought out from time to time for coating the face of the brick and thus extending its life. In some instances it has been difficult to prevent the wash from flaking off and leaving bare spots. A new protective coating, said to consist of a combination of granular refractories, has been brought out by the Keystone Refractories Co., 120 Liberty St., New York, under the trade name "Steel Veneer." It is painted on the face of the new brick and when subjected to heat forms a film that becomes part of the brick itself. Results at the Cumberland County Power Station, Portland, Me., and at one of the Southern central stations burning fuel oil with a high sulphur content, are claimed to have been highly satisfactory.

Efficiency Tests Made on 55,000-Horsepower Hydro-Electric Units*

By H. G. ACRES
Chief Hydraulic Engineer,
Hydro-Electric Power Commission of Ontario

BETWEEN 32,000 and 63,000-hp. load an efficiency of 90 per cent and over was obtained for the turbine, with a maximum efficiency of 93.5 per cent. A maximum over-all efficiency of 91 per cent was developed for the complete unit. The Gibson method of measuring the flow is described and the pressure-time diagram analyzed.

THE over-all maximum efficiency of the units in the Queenston plant of the Hydro-Electric Power Commission of Ontario[1] is well beyond 90 per cent, and within their maximum efficiency range they deliver about 32 electrical horsepower to the switchboard for every second-foot of water supplied under 305 ft. of net head. Under such conditions a variation of 1 per cent on one of these 55,000-hp. machines would mean either the lack or the availability of sufficient power to meet the requirements of an average community of 2,000 population. This statement should serve to emphasize the significance of high efficiency as related to super-turbine[2] practice.

The primary factor making for high efficiency is a minimum of obstruction to the direct flow of water from forebay to tailrace. This consideration involves water passages of ample section, with changes in direction of flow eliminated wherever possible, and where unavoidable, careful proportioning and transitioning.

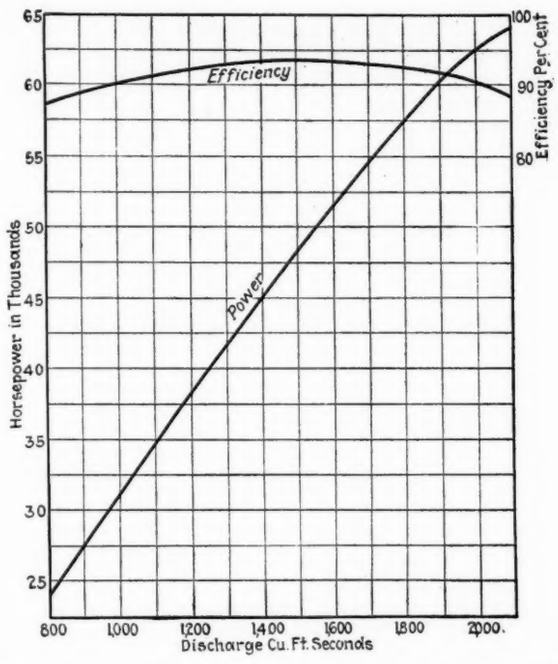


FIG. 1—POWER-DISCHARGE AND TURBINE-EFFICIENCY CURVES

These requirements constitute the general definition of high efficiency, and are exemplified in the carefully designed annular water passages in the Johnson valve, wheel case, speed ring, runner and draft tube of the modern super-turbine and also in the total elimination of one change in direction of flow entering the wheelcase, by vertically suspending the revolving weight from a Kingsbury-type bearing. Secondary, but none the less significant factors, are the elimination of leakage,

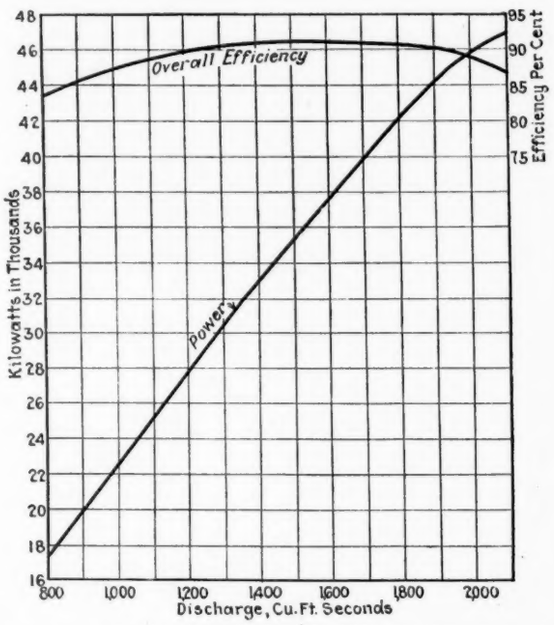


FIG. 2—OVER-ALL EFFICIENCY AND POWER-DISCHARGE CURVES

low power in thrust and guide bearings, and expert shop work.

The proper handling and co-relation of these various factors is exemplified in the curves, Fig. 1, which show the efficiency and power-discharge curves for one of the Queenston turbines. The matters of interest in connection with these curves are as follows: (1) The maximum efficiency is 93.5 per cent; (2) the efficiency at the point of maximum discharge is 88 per cent; (3) the turbine has a capacity range of 32,000 to 63,000 hp. at efficiencies of 90 per cent or over, and a capacity range of 37,000 to 60,000 hp. at efficiencies of 92 per cent or over.

Fig. 2 shows the over-all switchboard-efficiency curve of the same unit and indicates a maximum over-all efficiency of 91 per cent. The outstanding fact in connection with these results is that the modern super-turbine is capable of converting into mechanical energy all but less than 7 per cent of the gross potentiality of

*Abstract from "Refinements in Design of Large-Capacity Hydraulic Turbines," a paper presented at the Spring Meeting of the American Society of Mechanical Engineers, held in Montreal, May 29, 1923.

[1]Described in *Power*, June 27, July 11 and Aug. 22, 1922.

[2]A super-turbine has been defined by the author as one having a capacity of not less than 25,000 hp. and a revolving weight, with the generator rotor, of not less than 200 tons, exclusive of the hydraulic thrust. This definition is applicable particularly to Francis-type turbines.

the water supplied. Extreme conservatism in the fixing of specific speed and the combined effect of further small refinements in the design of water passages may possibly raise this efficiency 1 per cent in the future, and may give the curve a slightly more advantageous shape, but it would really appear that the present-day super-turbine embodies the ultimate in respect of water economy at the point of best efficiency.

Fig. 3 is an interesting curve representing the first derivative of the power-discharge curve of one of the Queenston turbines. As its name implies, this curve is derived by plotting the horsepower per second-foot in various regions of gate opening at and beyond the point of maximum efficiency, by a small opening movement of the gates. In other words it shows, not the gain, but the rate of gain in power for increasing water input. It will be seen that when operating at the point of maximum efficiency with a water input of 1,600 sec.-ft., the gain in power for one additional second-foot supplied is 32 hp. On the other hand, at full gate, when the turbine is taking water to the extreme limit of gate opening, the gain in power for one additional second-foot supplied is only about 10.5 horsepower.

Best to Operate at Point of Highest Efficiency

These two extremes show that under high heads it is in the best interests of economy, as well as safety, to operate normally at the point of best efficiency, and to employ the excess capacity of an over-gated turbine for emergency purposes only and not for routine operation. This statement has an added significance, also, when the water supply is artificially stored. Furthermore, the point of maximum efficiency is also the point of minimum hydraulic loss and the rate of runner deterioration at this point must also be a minimum. From this point on, the rate of runner deterioration is an accelerating progression, directly related to the degree of over-gate.

The points in favor of gating the super-turbine back to the point of best efficiency are: First, safe and efficient operation, particularly where long pressure conduits are involved; second, economy in the use of water under high heads, where the gross potentiality per second-foot of water is great and where artificial storage is a factor; and third, on account of runner deterioration, particularly where runner replacement involves a material revenue loss. The matter of turbine gateage has not, in the past, received the attention it deserves by the purchaser. It does not particularly interest the manufacturer, and must be covered, if at all, by the customer's specifications.

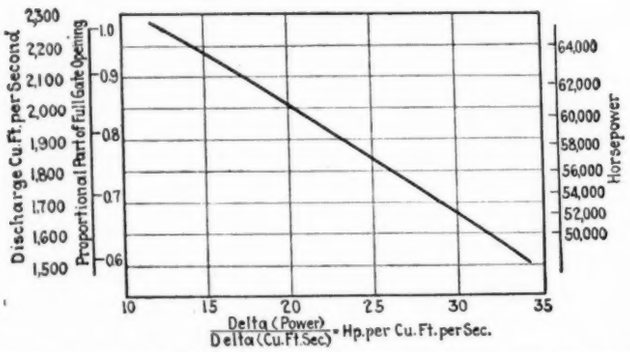


FIG. 3—CURVE SHOWING RATE OF GAIN IN POWER FOR INCREASE IN DISCHARGE

It would also appear that the main factor offsetting the foregoing argument is one of cost and not of engineering; namely, the additional cost, if any, of providing emergency plant capacity in the form of a separately installed unit or units, instead of relying on the over-gate capacity of the normal installation.

It may be stated in conclusion that generalizations have probably less weight in hydraulic work than in any other branch of engineering, as nearly every prospective installation is a problem in itself, and no class of construction work is less governed by precedent.

The factors entering into a turbine test are forebay- and tail water-level measurements, net-head measurements, records of gate opening and measurements of power and flow.

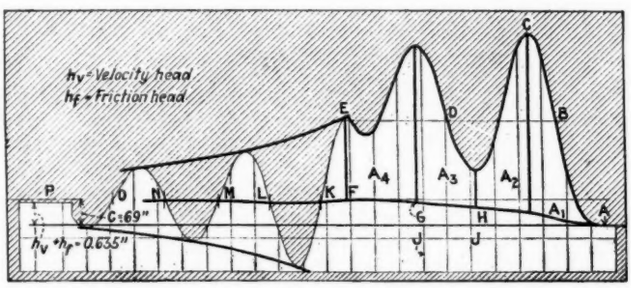


FIG. 4—PRESSURE-TIME DIAGRAM TAKEN BY GIBSON METHOD OF MEASURING WATER FLOW IN PENSTOCKS

Most of these factors are susceptible of easy and accurate determination by well-established methods, but in the case of flow the immense quantity of water taken by the modern super-turbine introduces a difficult problem concerning accurate measurement by ordinary means. There has recently been devised a method of flow measurement in closed pressure conduits, which by reason of its accuracy, cheap application and conformity to an established principle of natural law, entitles it to be classed among the essential advances in the hydraulic art, as related to super-turbine practice.

Gibson Process of Flow Measurement

This method of flow measurement, known as the Gibson Process,[3] is based in principle on Newton's second law of motion and on the less generally known theorem of Joukovsky, which is to the effect that when the velocity of flow in a closed pressure conduit is retarded, an oscillatory pressure wave is induced, the intensity and amplitude of which are proportional to the degree of retardation and to the duration of the period over which the retarding influence acts. Briefly, Gibson used the penstock and turbine gates to produce the Joukovsky pressure wave, which he records graphically with an apparatus of his own devising, and then reduces the result by the mathematical process of Newton's second law. The mathematical accuracy of the result is limited only by a relatively small instrumental and personal error involved in graphically recording and measuring the pressure wave.

The recording apparatus consists of a mercury U-tube connected to the penstock through a ¼-in. pipe. The glass leg of this U-tube is connected to a camera box containing a lens focused on a light-proof cylinder, the latter carrying a sensitized film and revolving at

[3]Developed by N. R. Gibson, hyd. eng., Niagara Falls Power Company. See *Power*, page 452, March 22, 1921.

constant speed behind an oscillating seconds pendulum. When gate closure occurs, the mercury column in front of the lens rises and falls with the pressure wave, and the record is printed on the revolving film. At the same time, the stem of the seconds pendulum, swinging across the face of the lens, records the time period of gate closure on the film, in the form of a vertical black line. Fig. 4 shows a typical pressure-time diagram thus obtained. Point *A* represents balanced conditions in the system just previous to gate closure. The distance from *A* to the vertical line *EF* represents the full-time period of gate closure. The oscillations to the left of the line *EF* are due to the mercury column stabilizing by friction, until at *P* static head is registered, with the penstock water column at rest. The vertical distance between points *A* and *P* therefore represents, to the scale of the diagram, the recovery of velocity and friction head. Lines *J* represent the second intervals recorded by the pendulum.

The total area above the base line, and to the point of gate closure at *F*, represents a total energy absorption containing three separate elements, velocity head, friction head and the destroyed momentum of the water column. This last element being the one required for the application of Newton's second law, it follows that the energy absorption due to recovery of velocity and friction head must be segregated.

The "Recovery Line"

At point *A* the full value of velocity and friction head is existent, while at *F*, the point of final gate closure, this energy has been fully recovered. The line *AHGF*, technically known as the "recovery line," divides the total energy area into two parts, the upper part of which *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H* represents the value sought; namely, the destroyed momentum of the water column. The area below the recovery line represents the sum of the other two elements, friction and velocity head. Intermediate points between *A* and *P* on this line are obtainable through the fact that the area generated at the end of any partial period of gate closure is proportional to the amount of flow reduction at that point, and also that the velocity and friction heads still unabsorbed are proportional to the square of the residual flow. The intermediate points *C* and *H* were determined on the basis of these relationships, through the medium of the measured sub-areas A_1, A_2, A_3 and A_4.

Fig. 5 shows a gate-opening-power and a gate-opening-discharge curve for one of the Queenston units. These curves are interesting in that they were compiled on the basis of two simultaneous but entirely independent series of measurements, in different sections of the penstock, by the Gibson process. The round dots on the curve represent the determination of Mr. Gibson himself, with his own assistants, and the triangular dots represent the determinations of the engineers of the Hydro-Electric Power Commission. The close agreement of these two series of discharge measurements affords striking evidence of the remarkable consistency and precision of the Gibson method of discharge measurement.

This test, with all the other necessary operations in connection with head and gate-opening measurements, etc., was made complete within about four and one-half hours, and included 28 separate runs at various gate openings, an average of ten minutes per run. The unit itself was out of commercial operation for about one hour altogether, showing clearly the facility and low cost with which the Gibson test can be carried out on an installed turbine.

An interesting feature of these tests manifested itself in an apparent inconsistency in some of the finally computed points for the efficiency curve, which varied for equal power outputs. This trouble was due to a discrepancy in the power readings, which were actually correct in themselves within the error limits of laboratory standards. The reason is that under the Gibson method the velocity measured is that existing at the instant the gates begin to move, and if the speed of the unit is perfectly uniform at this instant, the corresponding power reading will be correct for the measured discharge. If, however, at the instant of the flow measurement, the unit is in process of a speed change even so small as to be unnoticed on the frequency meter or tachometer, an error will be introduced in the electrical-power measurement which the Gibson process is sufficiently precise to detect as illustrated in this instance.

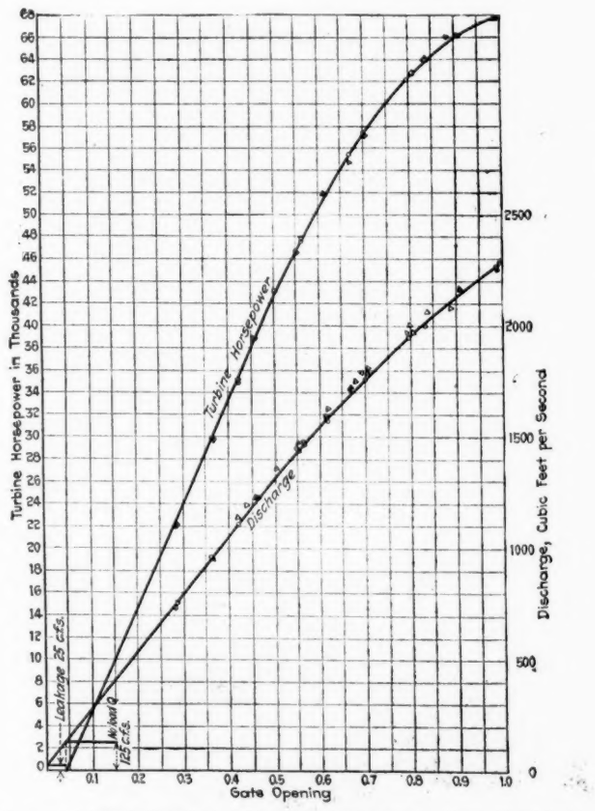


FIG. 5.—GATE-OPENING-DISCHARGE AND GATE-OPENING-POWER CURVES

The values represented by the small circles were obtained by N. R. Gibson, whereas values represented by the small triangles were obtained by the Hydro-Electric Power Commission engineer.

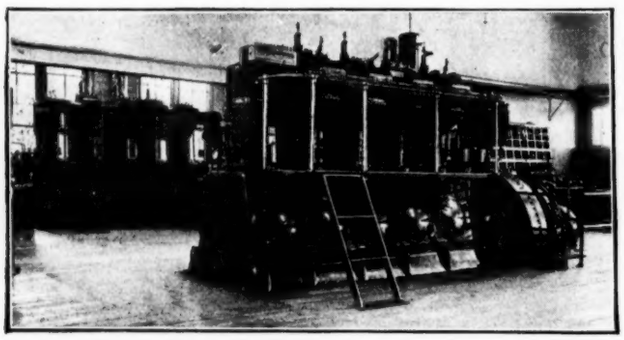
The flywheel effect of the Queenston generators is 21,000,000 ft.-lb. squared. If, at the instant of a flow determination, the speed of the unit is dropping at a rate of one cycle in ten seconds, there is 570 hp. registered on the wattmeters which the "WR^2" of the generator is supplying, but not the water as measured. Conversely, if the speed of the unit is in process of increase at the rate of one cycle in ten seconds, there is 570 hp. which is not being registered on the wattmeters, but which the water, as measured, is actually supplying, for absorption by the generator "WR^2."

This means that for any one value of discharge there may be any number of wattmeter measurements which may possibly be in error in any amount up to 1,000 hp. It is possible that this disability may be overcome by devising some simple means of recording the minute speed change of the unit synchronously with the instant of flow measurement, and thus permit a proper correction to be applied to the power readings.

The use of the Gibson process is limited to conditions that are properly conducive to the production of the phenomena upon which the theory is based, the first essential being a closed pressure conduit of reasonable length and uniform section. In short conduits of, say, 50 to 60 ft. in length, more especially if they have at the same time a non-uniform section, it becomes necessary to apply correction factors that have a greater relative influence on the ultimate accuracy of the result than is the case with long conduits of uniform section. The recently devised Allen "salt-velocity" method[4] of measuring flow is susceptible of application to short as well as long conduits and to non-uniform as well as uniform sections, the accuracy of the final result being dependent, not on an instantaneous pressure rise, but on the refinement of the equipment applied to the injection of a salt solution, the time of passage of which, through a fixed length of conduit, forms the basis of the final computation. The writer is not sufficiently familiar with this method to attempt a detailed description, but recent practical applications appear to indicate that it has a really useful function and will become a generally recognized process as related to this branch of hydraulic engineering.

Oil Engine Operating Costs

The small central station is facing the serious problem of high generating costs by reason of increasing labor and coal prices. The Holstein Service Co., of Holstein, Iowa, solved this by installing Diesel oil engines. The



DIESEL ENGINES IN HOLSTEIN PLANT

first of the units was a 165-hp. Busch-Sulzer engine, which was installed in 1917, followed by a 180-hp. engine of the same make erected in 1920. A view of these two units appears in the illustration.

In the table is given the operating record for 1922. It will be noticed that the average kilowatt-hour output per gallon of fuel oil was 9.44. This, in view of the low load factor, is excellent. The total operating cost per kilowatt-hour of 1½ cents is much below the costs in most central stations of like capacity. The only item that is excessive is the cost of attendance. This, however, is unavoidable in small plants since it is necessary to have three engineers, and in many steam plants three firemen would be required in addition. The output could have been doubled without increasing the number of men, with a consequent reduction of 50 per cent in the labor costs per kilowatt-hour. The yearly repair item of $95.94 shows that, contrary to the opinion of many, oil-engine repairs are not a serious item in plants where the engineers are high grade.

OPERATING RECORD FOR 1922

	Kw.-Hr. Output	Fuel Oil Gal.	Lub. Oil Gal.	Kw.-Hr. per Gal. Fuel
January	47,896	5,189	57	9.2
February	43,584	4,709	53	9.2
March	49,380	5,297	52	9.3
April	46,642	5,012	46	9.3
May	48,950	5,176	55	9.5
June	49,856	5,015	47	9.9
July	48,101	4,850	47	9.9
August	50,115	5,252	45	9.6
September	49,460	5,220	44	9.5
October	50,110	5,307	46	9.4
November	49,076	5,276	51	9.3
December	48,420	5,282	50	9.2
Total	581,590	61,585	593	....
Average	48,466	5,132	49	9.44

Operating Cost

Fuel oil, 61,585 gal. @ 5.6c	$3,448.76
Lubricating oil 593 gal. @ 68.3c	405.02
Attendance (3 engineers)	4,800.00
Engine repairs	95.94
Total	$8,749.72

Operating Cost per Kw.-Hr.

Fuel oil	$0.0059
Lubricating oil	0.0007
Attendance	0.0082
Repairs	0.0002
Total average cost for 581,590 kw.-hr. generated	$0.0150

Where the coils in an armature winding are wound with a single conductor, an open-circuit in one coil creates an open in the winding, which is manifested at the commutator by sparking at the brushes and a burned spot between the segments to which the coil leads connect. With a coil wound with parallel conductors, one winding could be open-circuited and the other would complete the circuit. This might result in heating the coil to a temperature where the insulation would be destroyed, since it would be carrying double current. Sparking might also exist at the brushes, but not to the same extent as where the coil is wound with a single conductor. If the machine was operating under light-load conditions, it might continue indefinitely with one winding open in a coil without giving any signs of distress.

Broken baffles are often the cause of high temperature of the chimney gases, since they permit them to short-circuit directly from the furnace to the flue, without deflecting them through their otherwise tortuous path. The importance of maintaining boiler baffles in good repair is too often neglected, because it is at best a mean job. In this connection we might mention that the solid-type baffles on the market today have justified themselves on more than one occasion. They present a solid wall to the path of the gases and afford no cracks through which some of the gases may be short-circuited without giving up their heat to the boiler.—*J. T. Beard, 2nd, in Industrial Management.*

[4]Developed by Charles M. Allen, prof. hyd. engr., Worcester Polytechnic Institute, Worcester, Mass. See *Power*, page 1038, June 29, 1923.

Reminiscences of a Veteran Mechanical Engineer—VI

Accounts of the First Meetings with Thomas A. Edison and Park Benjamin in Connection with Boiler and Indicator Work

By W. H. ODELL

The next installment of the Reminiscences takes up an amusing incident connected with the author's first meeting with Theodore Vail.

DURING the early eighties I was in active charge of the power plant of a mill in New York City, the plant having been selected by me a few years previously. It became necessary to purchase more boiler power, and I had designed a boiler for burning bituminous coal that would probably be accepted under the A. S. M. E. Code of the present day, but unfortunately it was not ordered by the management for two reasons—first, because it would cost more to build than would the regular stock boiler of the same size as manufactured; second, and principally, because one of the largest stockholders of the mill was financially interested in the promotion of a new type of boiler that was guaranteed to develop a very high rate of efficiency but which, as the sequel will show, developed only a high rate of profanity.

This boiler, installed much against my will, had been in use about three months when a representative of Mr. Edison called to investigate, as at that time Mr. Edison and his associates were trying to decide on what type of boiler would be best for the large electric-light plants it was proposed to build.

The Boiler Sheds Its Scales

I think the name of this man, who called to investigate, was Clark, but am not sure at this late date. However, in introducing himself he said that Mr. Edison had been told that this boiler had been installed much against my will, but that since I had experience with it I "praised it to the skies." This, to use a slang expression, "got my goat." I took out my log-book and showed that while the boiler had been promised the first week in September, it had not been delivered until December; then after three days under steam it was shut down for four days for repairs, and approximately that had been the record for the entire three months. Then, when escorting him out to see this gem of a steam boiler, I managed to take him past a good-sized pile of cracked cast-iron plates, which I had replaced with wrought-iron ones, and a lot of bolts and other fittings that had given out. This pile of defective material caught Mr. Clark's eye, and he wanted to know all about it. When told they were the scales shed from this so-called wonderful boiler, that settled the interview except that he wanted to take my log-book back with him to show Mr. Edison.

This request had to be refused, as the book was not my personal property, but he was assured it would be presented for inspection at any convenient time and place appointed, and it was arranged that an interview should be had that same evening at the exhibition of the light then being held in South Fifth Avenue, if I remember rightly, just below Fourteenth Street, and here I for the first time met another man whose name will endure, and another friendship was formed that lasted until the press of "big business" events left me far behind the band wagon. However, after studying the record some time, Mr. Edison looked up and with that quizzical method of his said, "A curve could be plotted that would show just when the boiler would have to be cut out again." This remark appealed to me and some years later on, when I met him, he referred to this interview and I was greatly impressed with his wonderful memory.

THOMAS A. EDISON IN 1878
Drawn from an old engraving

As already stated, this first exhibition of the incandescent electric light was held in a building on the east side of Fifth Avenue, just below Fourteenth Street. The two dynamos were driven with gas engines operated with illuminating gas from the street mains, as the present gasoline engine was not on the market at that time, and it was at this place that the question of the type of boiler for power purposes was often dis-

cussed. The New Root Boiler had not been designed at that time, nor had any other that seemed to compete with the Babcock, then known as the New York Safety Steam Boiler Co.'s boiler, as the present Babcock & Wilcox Boiler Co. had not been formed. However, I had done considerable work for the New York Safety Steam Power Co., and the merits of the Babcock boiler were urged, and the fact that so many thousands of horsepower of this boiler has since been installed by the various electric-light stations is fair evidence that the choice was well made, for in those days little was known about the water-tube boiler, or Mr. Edison's dream of the superpower plant.

Novel Exhibition of Electric Light

In order to interest more fully the public in this new light, an exhibition light was placed in one of the show windows of a drug store under the Fifth Avenue Hotel on the Broadway side. This light burned in a large glass globe filled with water and under the surface, and it attracted a vast crowd in the midst of which was a well-known practical joker of that day, who had become familiar with the operation of the light. One evening, seeing an acquaintance interested in the light, he asked what he thought of it, and among other good qualities the visitor ventured the remark that it would be of great value in deep-sea work because of its ability to burn under water, etc. To this the jokesmith replied "Nonsense, it is all right there in the store window, but as soon as it is taken out of doors the wind will blow it out." After quite a heated argument a bet was made that if the visitor blew in the bowl the light would go out, and just as the demonstration was made the switch was turned and the light, as a matter of course, went out and, as had previously been arranged, the attendant stepped up and made a great fuss, wanted to know who blew the light out, etc.; but the matter was settled without the shedding of any blood, on the visitor's agreeing to pay for the (pre-Volstead) refreshments for the gang that was in on the joke, and the moral of this is that it is not always the country Rube who has it put over on him.

Looking back over the few short years and contemplating the wonderful strides electricity has made, it seems more wonderful than the fairy tale of Aladdin and his wonderful lamp, for Aladdin had to bone down to it and rub his wonderful lamp before he could produce results, but now all we have to do is to touch a little peg and the deepest darkness becomes as light as day, or we can talk with a person miles away, and do many other wonderful things, and yet with all our research, etc., who knows what electricity is or what other wonders it may produce?

Mr. Benjamin Notices Indicator Location

But returning to that mill, which was the indirect cause of my meeting Mr. Edison, there was another event that occurred there and that may be worth recording here. About that time there was much discussion among writers for the technical press as to the proper location of the steam-engine indicator when taking cards from an engine. I had proved to my own satisfaction that midway on the cylinder was the proper place, for a medium-sized engine, and the mill engine was piped up in that way, but with the provision for taking cards with shorter connections on each end if desired.

The engine room of this mill was one of the show places for visitors, and one day the manager came in with the late Park Benjamin, who instantly noted the position of my indicator and asked if I would show or give him a card of each end. I looked over a lot of cards and selected one from the crank end taken when the load was very heavy, and one from the head end at a time when the load was light. My thought was to show the valve motion as perfect, regardless of the load on the engine. Shortly after Mr. Benjamin had gone, the manager came in again and wanted to know

PARK BENJAMIN

if I had any objection to Mr. Benjamin's sending a man to take a few cards with his own indicator. Of course I had no objection, and the next morning in came the late Alfred Wolf, with whom I was fairly well acquainted, and who, as soon as he saw me, repeated the same question asked some years previous when I was discovered in the Worthington Works at the Erie Basin, Brooklyn.

He did not care to take any cards, but I prevailed on him to thrash that mooted question out to his satisfaction. The indicators were moved from place to place, the ends and center positions being in operation at the same time but no difference could be detected, and I thought this ghost had been laid away for all time, but I see some of our newly graduated are inclined to revive it again. It came out in our conversation that day that either the cards did not have the proper data on them, or Mr. Benjamin had neglected to note that fact, and the impression had been made that the load was not properly balanced. This merely shows it is not safe to drive ahead until one is sure one is right.

EDITORIALS

F. R. LOW, EDITOR

Doing Away with Steam Power

HENDRIK VAN LOON, in his extremely interesting "Story of Mankind," makes a statement, pardonable perhaps in one only incidentally interested in mechanical things, which shows how well-educated men may entertain certain common fallacies in engineering matters. In discussing the evolution of power and its effect on civilization, he hazards the opinion that the clean and convenient "electric engine," driven by water power, will some day entirely replace the steam plant, with its smoke and dirt.

The answer to this is so well known to engineers that it may seem a waste of time to repeat it. If all the water power in existence in the United States were utilized, it could not supply our present power consumption and would be only a small fraction of our estimated consumption twenty years hence. We will, of course, develop our water power more and more, but water cannot "replace" steam, unless the inhabitants of this country are content to use far less power. This does not prove that steam power cannot or will not be replaced by some other kind, but it does prove, for all practical purposes, that water power cannot do the replacing to any great extent.

There is still room for argument as to the future possibilities of internal-combustion engines. These have already made much progress in certain types of plants. Then, of course, one must always admit the possibility of the future generation of power from coal by some more direct means, or the recovery of energy from the sun's heat or other natural sources. These latter, while of great interest from the scientific point of view, give little promise of any extensive commercial application within the lifetime of the present generation.

Engine Cooling Water Systems

AN OBJECTION often raised against the internal-combustion engine, especially of the oil-burning type, is that fractures of cylinders are so frequent as to make the maintenance charges excessive. While even in extreme cases such mishaps do not greatly influence operating costs, nevertheless the delays occasioned by such fractures are to be avoided as is also the cost of welding or replacement.

Almost invariably, upon investigation it has been found that such fractures occur only when the cooling water is bad and the engine heavily loaded. Poor head design has some influence, but only a slight one compared to the action of the cooling water. The most available source of water supply is generally used without consideration of its percentage of hardness or the character of the minerals carried in solution. In fact, in certain localities in the Southwest the water is so hard that a deposit of one-quarter inch of scale on the cylinder walls in a month is not infrequent. All this trouble may be avoided by the expenditure of a few hundred dollars in a closed-type cooling-water system. Water flowing through the engine jackets should be pure, and evaporation loss may be prevented by making the system a closed one. This water, after picking up a supply of heat from the engine, can be cooled by the use of raw water of any degree of hardness. Ammonia condensers of the atmospheric type make an ideal cooling-water cooler and have been installed in a number of plants. They have the advantage of being comparatively low in price per horsepower capacity.

The system of treating cooling water in order to change the minerals from those that are merely held in suspension into minerals that are in solution has been used in a few plants and has proved satisfactory. The cost of such treating systems will often prove to be less than the cost of condenser coils.

In view of the freedom from scale and engine troubles such cooling systems bring about, it is a matter of surprise that the engine manufacturer does not incorporate one of them in the list of equipment furnished with the engine.

Efficiency of Hydro-Electric Units

ONE could hardly pay a higher tribute to those who are responsible for the high state of hydro-electric equipment than to say that with large units operating under medium heads it is possible to deliver ninety-one per cent of the gross energy in the water, due to the static head between the forebay and tailwater elevations, on the generator busbars. This has been accomplished in the Queenston plant of the Hydro-Electric Power Commission of Ontario, at Niagara Falls, as described elsewhere in this issue, in the article "Efficiency Tests Made on Fifty-five Thousand-Horsepower Hydro-Electric Units," by H. G. Acres. These efficiencies are so high one might be inclined to doubt their correctness if the tests had not been made by a method that can be applied with a high degree of accuracy. Furthermore, simultaneous tests made on the same unit by two independent groups of engineers show a close similarity in results.

Tests made on the 37,500-horsepower units of the Niagara Falls Power Company in 1920 showed an over-all efficiency from forebay to switchboard of over ninety per cent. Further refinements in design may raise the over-all efficiency of large hydro-electric units in the future, but at best the gain can be only one or two per cent. When the 70,000-horsepower machines of the Niagara Falls Power Company go into operation the latter part of this year, it is probable they will show a slightly better efficiency than the Queenston machines. They are about twenty-five per cent larger than their predecessors, but will operate under ninety feet less head.

This high state of development in the art of designing hydro-electric units has come about in the last twenty years and has been due to the demand for larger units and to a better understanding of the fundamentals of design. Previous to 1900 the design of

hydraulic turbines in this country was very largely a cut-and-try process. The largest turbine installed at that time was a 5,000-horsepower unit that had an efficiency of sixty-three per cent at fifty per cent rated power and eighty per cent at rated load with the efficiency curve inclining sharply upward, showing that the maximum efficiency would occur at a point never intended by the designer. With the Niagara Falls turbines installed in 1919 and 1920 an efficiency of ninety per cent and over was obtained at loads ranging from fifty to one-hundred per cent, with a maximum of ninety-three per cent between seventy and eighty-five per cent rated load. On the Queenston turbines an efficiency of ninety per cent and over was obtained for a range of load between sixty and one hundred and fourteen per cent rated power and ninety-two per cent and over for loads between seventy and one hundred and nine per cent of the turbine's rated power, with a maximum efficiency of ninety-three and one-half per cent at eighty-eight per cent of full rated load of the turbine. These results show that improvement in hydraulic turbine design has not only raised the maximum efficiency of the unit, but has also flattened the curve out so as to give a wide operating range at high efficiency, with the maximum efficiency occurring at about what would be the average loading of the unit.

Since the efficiency of the hydraulic turbine is about as high as can ever be expected, it devolved upon those intrusted with the development of water power to build not alone for today, but for the future. Any mistake made in a water-power development cannot be corrected at some future time when the installation of more efficient machinery will be developed as in the case of a steam station. Improvements in design will be made in the hydraulic turbine, but these will be more in the form of refinement of mechanical details than in those features that improve efficiency.

More Information Required on Elevator-Cable Life

WHAT determines the life of an elevator cable is a mooted question. It is known that the size of sheaves, number and kind of bends, loading, number of trips per car mile, kind of machine and service, use of lubrication, methods used in installing the cables, kind of material, methods of manufacture and other factors all have an influence on the number of car miles that may be expected from a set of elevator cables, but the value of each factor in the equation is something that no one has determined. In fact, little effort has been made to determine the effect of each element on cable life. For this reason the report covering a period of nine years of cable service on twelve elevators in a modern skyscraper building, published in this issue, is of particular interest. The report involves forty-five sets of hoisting cables and fifty-two governor cables.

In studying this report one is impressed with the wide variation in the life of cables made of the same material and by the same manufacturer. As an example of this, on each elevator, the first cables installed, which are of traction steel, have some of them had over three times the life of other sets, operated under apparently the same conditions. This variation appears on both the high-rise and low-rise cars. When different materials are included in this comparison, the variation in life is as high as seven to one for cables operating under apparently the same conditions. When a set of cables will give a mileage of over forty-eight thousand and another set made of different material gives less than seven thousand, it should be sufficient to convince the most skeptical operating engineer that a careful record of cable operation is important and that the purchase of elevator cables is something more than buying so much wire rope.

It would be difficult to draw any very definite conclusions from the report, even though Mr. Garrison has satisfied himself that the present six by nineteen cable is not flexible enough and has decided to use eight by nineteen. It is too early to draw any conclusion from the service records from these latter cables.

That the number of times a cable bends per mile of car travel is an important factor in its life is definitely established by the records given in this report. The average life of the cables on the low-rise cars compared with that on the high-rise cars shows that the mileage varies approximately inversely as the trips per car mile. Of course this should not be taken as a fixed ratio without more data to bear out these results.

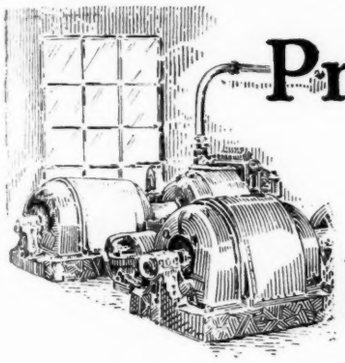
In the investigation made to determine the condition of the cable no broken wires were found inside the strands. All broken wires were found on the surface of the cable, where they could be seen. This probably can be depended on as being true in all cases where the cables are properly lubricated. Elevator cables have been found which, from all outward appearances were in good condition, but when taken apart were found to have a number of broken wires on the inside of the strands. This was probably due to the lack of lubrication in the cables causing excessive strains to be set up as they bend around the sheaves.

The information made available by Mr. Garrison is worth more than all the opinions based on supposition that have ever been expressed regarding elevator-cable life. It is to be hoped that other engineers will follow his example and take the trouble to make available operating data on elevator cables. This cannot be done in a day or a month, but requires years of operation.

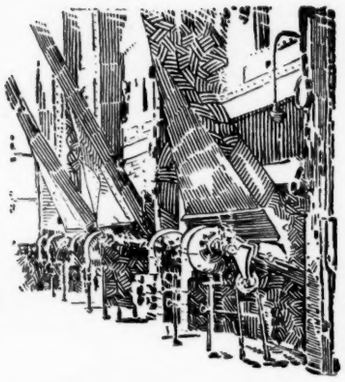
Lack of organization and a great number of mines under independent ownership has often been given as one of the reasons for chaotic conditions in the bituminous fields with consequent instability of prices. Such conditions may be economically unsound and result in lower profits to the producer, but from the consumer's point of view they are preferable to those in the anthracite industry, where the ownership and control are in the hands of a small group and where prices have showed a steady increase.

Inspired, possibly, by the success of the installation at the plant of the Chase Metal Works in Waterbury, Conn., a number of industrial plants are arranging to heat buildings with condenser circulating water. Combining the recovery of exhaust heat with turbine or engine operation under a worth-while vacuum, this method of operation seems to offer great possibilities of fuel saving.

The battle which Governor Baxter of Maine has been waging with certain water-power interests still continues, and as a result Maine now finds herself without a Water Power Commission. She is not alone, however, for water power appears to have lately become an attractive political football in several states.



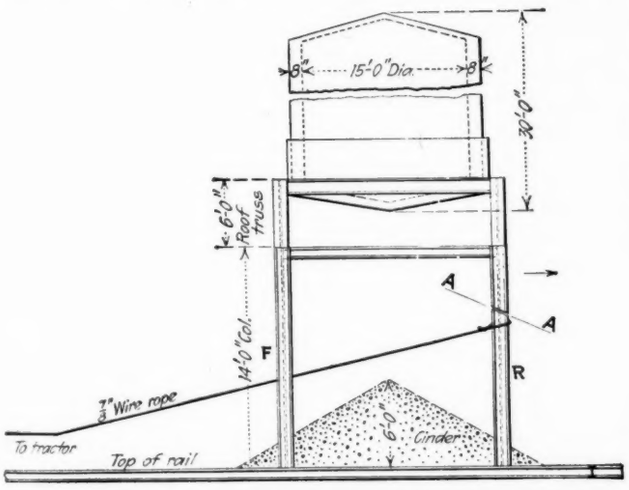
Practical Ideas *from* Practical Men



Quick Method of Razing Concrete Ash Bin

I once had charge, with another engineer, of the dismantling and disposing of an old plant, and many problems confronted us. There was an ash storage bin 15 ft. in diameter by 30 ft. high made of reinforced concrete 8 in. thick. It was supported by columns and by the roof trusses of the coal shed. The bin was about 20 ft. above the top of the rails.

There were two ways to attack the problem. One was to build a platform and false work around the bin and break it up in the air, which would be an expensive



TWO COLUMNS OF SUPPORTING STRUCTURE WERE CUT, THEN DRAWN CLEAR BY TRACTOR

job; the other method was to cut the rear supporting columns and bring the whole structure to collapse. We decided on the latter.

The two rear columns *R* were cut along the line *AA* with an oxyacetylene torch. Below this line we tied ⅞-in. wire ropes, which were united at a suitable distance and attached to a tractor. The lower part of the columns *R* were drawn away from the upper part, and at the same time the bases of the uncut columns *F* became the pivot around which the whole structure started to sway gently, the center of gravity was displaced and the structure fell in the direction of the arrow to the ground. To break the fall somewhat and to dampen the noise, we placed cinders about 6 ft. high under the structure before it was brought to collapse. The bin was so completely broken up by the fall that the rest of the work was of short duration.

Chicago, Ill. IGNACIO IZSAK.

Broken Governor Spring Causes Engine Wreck

It has become common practice among engineers, when making repairs to engines or other equipment, to have the broken part welded by the electric or oxy-acetylene process instead of replacing with a new part. That this is not always wise or practical was demonstrated recently by the wreck at our plant of a Corliss engine that was direct connected to a 300-kw. generator.

The governor of the engine was of the flywheel type, and previous to the accident a leaf in the spring had broken and was welded and put back into service. The engine had been running only a short time when the spring broke again at the weld, allowing the engine to run away. The governor was completely wrecked and considerable damage was done to the engine. The engineer on duty was unable to reach the throttle valve, so had to close a valve on the main header.

Fortunately, no one was hurt and the main shaft of the engine was not damaged. We were seriously handicapped, however, in making repairs, as this particular engine is no longer manufactured and we had to make new parts by using the broken pieces as patterns.

Harrisburg, Ill. STEWART ROGERS.

Water Gages and Their Care

Gage glasses frequently break and must be replaced. This operation requires much care, and I believe that no better information can be found on the subject than that given in an article entitled "Water Gages and Their Care," by Charles S. Blake, president of The Hartford Steam Boiler Inspection & Insurance Co., in the January, 1922, issue of *The Locomotive*. Two paragraphs of this article follow:

All glasses are keenly susceptible to surface abrasions, even so minute as to be unobservable. If one receives the slightest scratch inside or out, it should not be used, and in handling or keeping them in stock, no metal of any nature should be allowed to come in contact with them. They are particularly liable to break if iron or steel touches them, and so should never be laid down even temporarily with tools, as is frequently done in preparation for a renewal.

The great precaution is to keep the surface from being scratched, for, as every engineer knows, it requires but the slightest breaking of the skin of the glass in a circumferential way to cause it to almost fall apart. The peculiar phenomenon of the glass breaking which has lain next to iron or steel has never been explained to me; but I have a number of times as an experiment taken a glass, run a smooth rod of iron through it and put it away. Sooner or later it has been found shattered in many pieces. My first observation of this phenomenon was when I placed a glass on a shelf in an engine room with a large pocket

knife against it to keep it from rolling off. The next day I found the glass all in pieces, but the pieces in their respective positions, showing that the breakage was not from violence else the pieces would have been scattered.

To test out the foregoing theory, I took two ¾ x 12-in. gage glasses, run a rough rod of iron through them and put them away in a wooden box, then put more than a pound of small scrap iron and steel in small pieces in the same box, and made sure that every piece was touching the glass.

They were left in this way for some months and were then taken from the box and put in use as water gages on boilers carrying 150 lb. pressure. This was five months ago, and they are still in use.

I would not recommend anyone to put in use any gage glass that has been scratched, but from the experience related I do not believe that iron or steel just coming in contact does injure a gage glass.

Norway, Mich. THOMAS J. PASCOE, Master Mechanic.

Improved Generator Connections

In the plant of which I have charge there are two generators, one of which is a 175-kva. 200-r.p.m. 480-volt 60-cycle three-phase direct-connected generator to a steam engine. A 10-kw. compound-wound exciter for this unit stands on the floor, is belt-driven from a pulley on the engine shaft and runs at 680 r.p.m. The larger unit is a 800-kva. 150-r.p.m. machine. The frame of this machine is so designed that it may be moved parallel to the shaft on the bedplate sufficiently to render both the stator winding and the revolving field accessible for repair. A 30-kw. compound-wound exciter for this generator rests on a bracket cast on the outboard bearing and is driven by an inclosed silent-chain drive at 680 r.p.m. The exciter current passes through the basement, the same as the main leads, to the switchboard rheostat, then returns to the field winding through collector rings secured on the main-shaft. The brush rigging is supported by a cast-iron

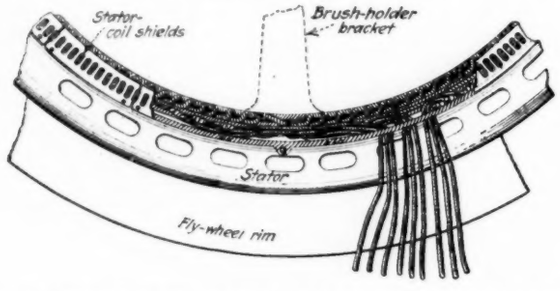
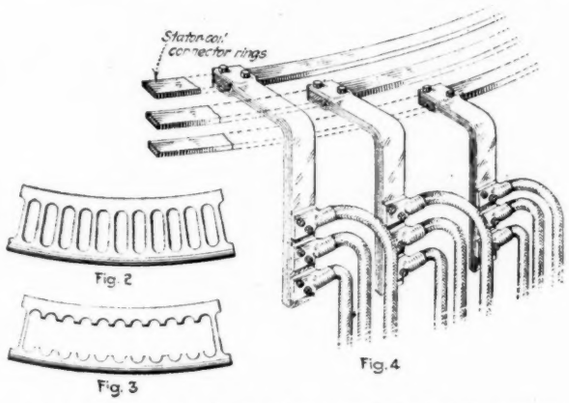


FIG. 1—SECTION OF STATOR FRAME SHOWING ORIGINAL ARRANGEMENT OF LEADS

bracket attached to the stator frame. The ends of the stator coils are protected by cast-iron end shields divided into 39 sections, and the brush-holder bracket occupies the space on the stator frame equal to one section of coil shield.

The plant was operated a little over a month, when about 20 coils burned out at the bottom of the stator, causing a shutdown of nearly two weeks. I was just coming up from the boiler room when a noise, similar to a pop valve going off, was heard coming from the engine room, which was found filled with smoke. As this occurred, the electrician happened to be in the engine room and quickly pulled the switch, or the damages might have been worse. The ends of the coil over the entering lead wires were melted away back of the brush-holder bracket, for a length of about two feet.

Fig. 1 shows the congested arrangement of the lead wires connected to the stator-coil connecting rings before the accident. When repairs were made, 20 new coils were put in and one of the coil shields was cut out, as shown in Fig. 3. Laminated copper strips ¾



FIGS. 2 TO 4—SHOWS HOW CONNECTIONS WERE CHANGED FROM THOSE IN FIG. 1

in. wide were bolted to the stator-coil connecting rings. These were wrapped with insulation tape, passed through the opening made in the coil shield, and the terminal leads bolted to them, as shown in Fig. 4. This arrangement did not have the neat appearance that the connections had before the change, but the leads are down in the wheel pit and are not noticeable. The machine has been in operation about a year and a half since the repair was made, and no trouble has been encountered. Sometimes there is a load as high as 1,200 amperes on this generator, which is rated at 962.

Two washers were placed on each capscrew, between the stator frame and coil shield, to move the shields away from the coils and give a little more room.

New Iberia, La. ANTHONY A. FETTE.

Getting Results with Defective Packing

Undoubtedly, there are many engineers who at some time or other have tried out new kinds of packing only to find them unsuitable for the purpose they were purchased for and had to discard them for a better quality. In some plants the stock of discarded packing increases from time to time and is eventually scrapped.

Recently, I had a little experience in this line myself. I bought a quantity of packing which later proved to be defective. Instead of laying it aside, however, I decided to use it in a stuffing box together with a few turns of good quality packing. I tried it on a 2½-in. high-pressure piston rod with good results.

In the bottom of the stuffing box I placed first a ring of good packing, then two rings of braided asbestos which had been well soaked in a mixture of hot cylinder oil and powdered graphite. On top of this I placed a few rings of the defective packing, then two more rings of asbestos and then finished filling the box with the defective packing. The gland was made moderately tight, the engine run for a short time, then the gland nuts were loosened up a little. In this way I got several months' service out of the packing.

Toronto, Ont., Canada. J. E. NOBLE.

Comments from Readers

Two Flywheels as Compared with One For Internal-Combustion Engines

In the March 6 issue of *Power* the article "Setting the Crankshaft Bearings of Internal-Combustion Engines," portrays conditions considerably at variance with those in the present-day multiple-cylinder internal-combustion engine of the two-stroke-cycle type.

It is granted that in the pioneer days of the four-stroke-cycle gas engine some crankshaft breakages were experienced with four-cylinder engines having two flywheels overhung. But we must not overlook the fact that the crankshafts in those engines were of much lighter construction than the present-day oil engine employs nor the advancement of the art and knowledge gained by the experience of the intervening years. To the man not very familiar with oil engines Mr. Shepherd's article is rather misleading, as the reader may assume that the theories expounded apply to modern practice, when in reality they are far from applicable.

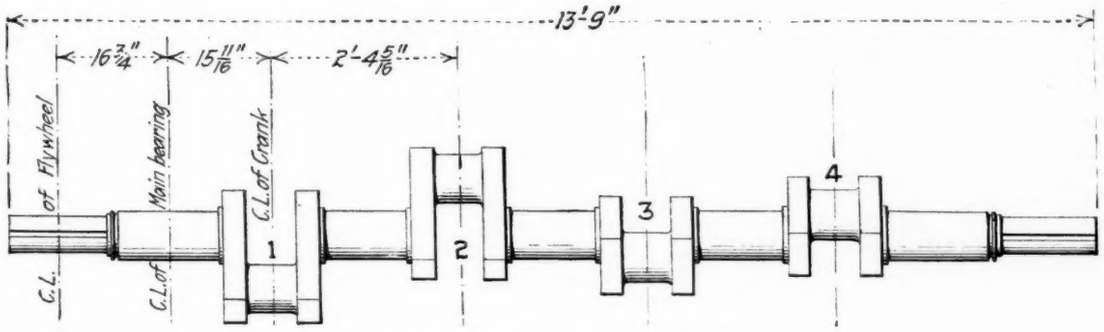
To illustrate my contentions, take the case of a vertical two-flywheel type, two-stroke-cycle oil engine, having four cylinders 14-in. bore by 18-in. stroke. Cylinders 1 and 2 have the throw of their respective cranks 180 deg. apart. Likewise, cylinders 3 and 4 have their cranks 180 deg. apart and are also set at 90 deg. to 1 and 2. The positions of the flywheels, bearings and cranks are shown in the illustration.

In a two-stroke-cycle engine cylinder the pressure is always one way, away from the head; hence all pressure in the vertical engine is exerted downward. As the engine under consideration compresses the air in the cylinder to approximately 315 lb. at the instant of oil injection, it is easy to compute the load on the shaft tending to offset any tendency of crankshaft to "bow" in the center from flywheel weight.

With cylinder 1 halfway down on its power stroke, cylinder 2 will be halfway on its compression stroke, cylinder 3 will be just at starting its power stroke and cylinder 4 just at starting its compression stroke. The pressure in cylinder 1 at this instant is approximately 80 lb. per sq.in., in cylinder 2 approximately 20 lb., in cylinder 3 315 lb. and in cylinder 4 atmospheric pressure.

The pressure in cylinder 1 places a total load on the crankshaft of 12,320 lb. plus the weight of the piston and rod, minus the back pressure of the crankcase air, the latter being more than offset by the dead weight of the piston and rod. Cylinder 2 places a load on the crankshaft of 3,080 lb., cylinder 3 a total load of 48,510 lb. and cylinder 4 no load other than the weight of the piston and rod, which I am disregarding as being negligible. The instant the oil is injected, the pressure in cylinder 3 is increased somewhat, so the values just given are a very good average of constant conditions. Here is a total load on the crankshaft of approximately 63,910 lb. acting to counteract the tendency of a pair of wheels each weighing 3,000 lb. to bow the shaft in the center.

My contention is that the overhung wheels on the modern two-stroke-cycle oil engine do not and cannot



FOUR-CYLINDER CRANKSHAFT

have anything to do with crankshaft failures when the shaft is of correct design. How infinitely better it is to have a series of bearings aligned at the factory and eliminate the necessity of putting in an adjustable outboard bearing for every installation, as is necessary when one flywheel is used.

A great many crankshaft failures with the one-flywheel type have been caused through misalignment, and there has never been a crankshaft failure in the overhung-flywheel design to which I refer in the foregoing.

Were it possible to be absolutely sure of permanent alignment of the outboard bearings, less trouble from this source might be anticipated, as they are made to serve as a part of the direct support for a very heavy flywheel. As these bearings are generally furnished with adjustable four-piece liners, it can easily be appreciated how misalignments can and do cause crankshaft failures.

The outboard bearing design is especially objectionable in direct-connected engine-generator units, where magnetic attraction would serve to float the shaft in the outboard bearing in case the armature is raised slightly above its true center.

There also is another element to consider in rigidly coupled units. The magnetic thrust imposes an elongating or compressing effect on the crankshaft which may result in broken crankshafts, generally at the

juncture of the crank webs. The two-flywheel type eliminates the necessity of an outboard bearing and a two-bearing generator may be flexibly coupled to the engine and all the foregoing difficulties easily surmounted.

The two-flywheel type has the decided advantage of being able to utilize drives on either or both flywheels. From many angles this flexibility is desirable. In addition the distribution of the flywheel weights causes much less distress to the adjacent main bearing.

The one-flywheel type can generally drive from but one end of the shaft and certainly is not to be recommended for a drive from the end not having any flywheel effect between the engine and the load. There is no disputing the fact that a flywheel of abnormal proportions interposed between the engine and the load will, on rapidly fluctuating loads, tend to remove in a large measure the shock to the engine.

With the two-flywheel design where stiff, liberally dimensioned crankshafts are employed no more shock to the engine results on fluctuating loads, as one half the flywheel effect is always between the engine and the load and the rigidity of the shaft makes the other half immediately available.

It is highly probable that some of the earlier crankshaft failures might be attributed to the tendency of the flywheel on the off-load side of the engine to overrun, the wheel absorbing most of the load fluctuations, and owing to the light crankshaft construction, the twisting effect produced in the crankshaft resulted in crystallization and failure.

As Mr. Shepherd predicates his article on his apprenticeship days, certainly readers will recognize that what was considered good practice in those days is no longer in vogue, as much has been learned since and his article in no wise pertains to the modern massively constructed two-stroke-cycle oil engines.

Atlanta, Ga. W. H. SINGLETON.

What Causes the Pump to Groan?

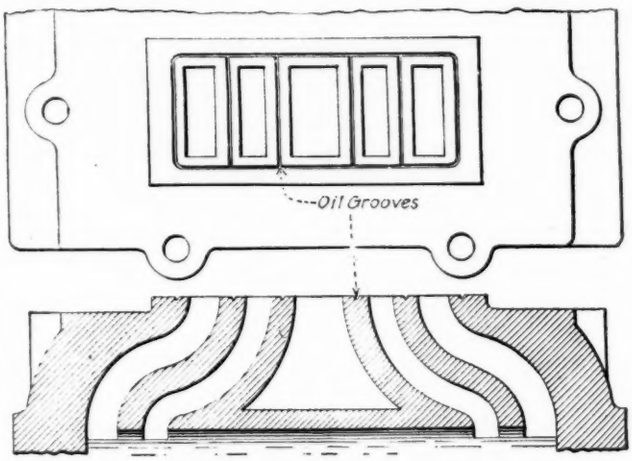
Referring to the request of P. Stewart in the May 15 issue for suggestions as to the cause of a groan in his pump, additional information as to the characteristics of the groan and more complete description of the pump would help *Power* readers to offer suggestions. Considering the groaning in a steam pump in a general way, the following observations and suggested remedies may be made to advantage:

Steam-end groans are usually caused by the friction of the steam slide valve on the cylinder face and may be corrected by improving the lubrication. If an oil groove is chipped in the bridge between the ports, as shown in the illustration, the lubrication will be considerably improved. A good grade of lard oil will lubricate the valve and should eliminate the groaning. A mixture of cylinder oil and graphite may also tend to relieve a groaning valve. A pump that gets dry steam is more likely to groan than one that gets wet steam.

If the pump groans the full length of the stroke, it is very likely a result of trouble in the steam end. If the groans occur only when the slide valve is moved, the trouble is due to a poorly lubricated valve. If the trouble is in the valve, it can be identified by feeling the valve rods, to see if they vibrate. The vibration of the rods indicates a groaning valve.

Groans usually develop in the steam end of the pump and usually at the slide valve. It is not clear from the description given whether the pump is of the plunger or piston type. If of the former, it may be out of line causing it to drag on the cylinder lining or the stuffing box. An examination of these parts should show whether or not the plunger drags. Perhaps the new sleeve in the pump cylinder and on the plunger may be of low-grade composition and the two metals are not adapted to work one on the other.

It is also stated in the article that when the pump is operating with the cylinder head removed, there is no groaning. This would indicate that the pump is of the plunger and ring, or inside-packed type. It is not surprising that the pump does not groan when the cylinder heads are removed, since under these conditions there is no load on it. Perhaps, in reassembling the plungers they were not assembled in line with the plunger rods. When the pump was repacked, it may have been packed too tight and the packing swelled in service.



GROOVES CUT IN CYLINDER FACE IMPROVE LUBRICATION

If the groan is a result of improper alignment of plunger or cylinder and located in the water end, it is likely to occur only at the end or at the beginning of the stroke.

It is hoped that these suggestions may be of value and if the groans continue, that Mr. Stewart will give a more complete description of the pump, and its service conditions. ROBERT E. NEWCOMB.

Holyoke, Mass.

Changing from Coal to Oil Fuel Does Not Eliminate Combustion Losses

In several articles that I have recently read stress has been laid on the fact that, in the use of fuel oil supplementing that of coal, the smoke nuisance and its attendant losses are done away with. Such a statement, whether intentional or not, is misleading, especially to the layman or to those who have had no experience with liquid fuels. To the executive who has in view any contemplated change from coal to fuel oil, such a thought would doubtless prove a vital factor in prompting his decision. It is the purpose of this article to disabuse, as far as possible, the mistaken idea harbored by the perfectly well-meaning layman, inexperienced operator or executive, regarding the smoke question.

Any man who is operating with oil as his fuel, will agree with me that it is possible to produce just as black and as wasteful a smoke with fuel oil as with coal. In a

majority of cases it is the under-atomization of the fuel oil or improper furnace design that is the cause. Any one of several other features may be responsible to a certain extent.

Assuming that furnace design and other vital requisites are proper, it naturally devolves that smoke can be caused from no other source than the improper handling of the burner valves. In the operation of fuel-oil-fired boilers the operator has every available heat unit, in a concentrated form, at his finger tips so to speak, and poor judgment on his part in atomizing the oil to admit of ready and thorough combustion will materially reduce his furnace efficiency.

In this part of the country, where little else but fuel oil is used in the generation of steam, the steam atomizing burner seems to have the preference. Why this is so, is problematical. True, there are a few mechanical atomizing installations, but the flat-flame burner seems the one best adapted to their mode of operation. The tendency of some mechanical burners to clog readily and the difficulty often experienced in obtaining perfect atomization at light loads are doubtless two reasons why they are used less extensively than the steam atomizing burner.

With the use of steam atomizing burners, however, any carbonizing or clogging effect is in a great measure reduced through the cooling medium of the atomizing steam. The steam, too, is of great help in cleaning the burner tip while in operation or in clearing the oil side of the burner from any small impurities.

Now to revert to the paramount question of smoke. In the firing of this type of burner the oil and steam control valves must be accurately manipulated under all load conditions so as to insure, at all times, the proper mixture or ratio of steam and oil so that perfect combustion may take place. Too little steam results in under-atomization and the aforementioned losses; too much steam results in over-atomization and an intense, white localized flame, destructive alike to tubes and furnaces.

It is evident that, in either case of misjudgment, losses may and do accumulate during a year's time that will cause the man who sanctioned the change to wonder whether his decision was wise or *otherwise*. So, it behooves that executive to place in charge of such operations a man capable of exercising sound common sense and unerring judgment as he passes the mixture through the burners, or he will run up losses as great in proportion as were those when coal was used.

Personally, I am a fuel oil enthusiast, and six years of contact with its use and its problems have brought me to the point where I regret the fact that in reading the technical journals I find relatively so little regarding it.

JOHN W. SHAW.

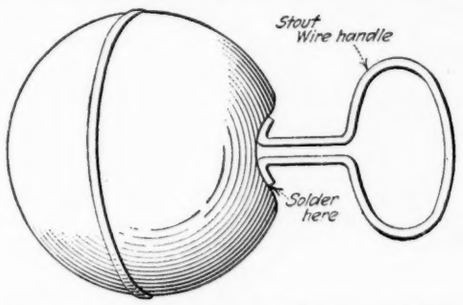
New Orleans, La.

Removing Dents on Copper Floats

The article by R. A. Hall in the May 29 issue, on "Straightening Copper Floats with the Aid of Air Pressure," was of interest to me, because removing and straightening out dents on metallic shells, closed cylindrical vessels, copper floats tubing, etc., is an important part of the work in the sheet-metal shop where I am employed. The following practical hints may be of interest to readers.

If the article is made of thin sheet metal and if there is no means of working from within, solder a piece of stout wire in the center of the indentation. After the solder has set, the wire can be given a strong pull so that the metal will be pulled outward. The wire can be finally melted off. A wire bent to form a handle as shown in the illlustration will be found to be a useful tool for this work. Sometimes, when the dent is not eliminated satisfactorily by this method, a few light hammer blows around the edges of the dent will greatly improve the appearance. If a polished copper or brass article has been dealt with, fine emery cloth should be used to remove every trace of solder, afterward rottenstone and oil should be used, finishing off with dry powdered lime. Buffing is used, of course, wherever highly polished surfaces are required.

In some cases it is possible to remove dents from spherical articles by lightly hammering the outer edges of the dents with a smooth-faced hammer until they disappear. The degree of success of this operation will depend, of course, on the thickness and characteristics of the metal and the skill of the workman. Dents $\frac{3}{4}$ in.



WIRE HANDLE SOLDERED IN DENT FACILITATES REMOVAL

in diameter and $\frac{5}{8}$ in. deep have been removed from 6-in. copper floats by this method.

If the article has an opening large enough to permit a suitable tool to enter, the dent or bulge can be straightened out by hammering. By placing the article on an iron tool and carefully hammering on each side of it, or around it, the original shape can be restored.

If the metal is too stiff to allow the dent to be forced outward, and the dent is not accessible for the hammering method, clean the indentation, and fill it with solder, then file level, after which the soldered surface should be smoothed off with fine emery cloth. All traces of the flux used for soldering should be thoroughly washed off to avoid subsequent corrosion of the metal. This method may not be suitable for copper floats, owing to the extra weight, but it is an economical method for filling dents on many classes of metallic objects.

To remove dents in copper tubing, obtain a number of steel balls, highly polished, and equal in diameter to the inner diameter of that part of the tubing which is undamaged. Anneal the copper in the immediate vicinity of the damage by heating it to a dull red and instantly plunging it into cold water. Drive the balls throughout the entire length of the tube. A little powdered black lead sprinkled among the balls in the tube will facilitate the work. Obviously, if the balls can be made to pass through the tube, the latter will be restored to its original shape.

In cases where copper tubing is bulged on the outside, obtain an iron plug and place it in the tube to serve as an anvil while hammering the bulge back to the original shape. Anneal the damaged portion of the tube as previously explained.

A. EYLES.

Manchester, England.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Forced Draft for Boilers

We have a 66-in. and a 72-in. return-tubular boiler, each provided with 6-in. diameter flues. Most of the time it is impossible to make enough steam, on account of the poor draft. Could there be any harm coming to these boilers with forced draft? L. S.

No more harm would be probable from forced draft than from burning the same amount of fuel with natural draft, provided the fires are carried with uniform thickness and the draft pressure is equally distributed over the grate areas. Unless the boilers are set at unusual heights, a forced draft, making its way through a small area of the fire, is likely to have a blow-pipe action and cause burning of the boiler shell from impingement of the hot furnace gases. Such concentration of the draft may be obviated by having the blower discharge into a "wind-box" that should be connected by a duct of large size, to reduce the velocity of the air to a minimum as it enters the ashpit.

A general objection to forced draft is that the draft pressure above the fire is likely to be greater than the pressure of the atmosphere, forcing heated gases and dust out of the firedoors and cracks in the boiler setting. More satisfactory results are to be obtained with an induced draft, as that system assures greater uniformity of combustion per square foot of grate, closer draft regulation and no annoyance from dust or hot gases blown out of the ashpit, furnace or other parts of the boiler setting.

Power for Pumping When Bypassing

A pressure gage in the highest point of a pipe line registers a pressure of 15 lb. per sq.in. when the pumps are delivering a normal supply of 6,000 gal. of water an hour. At this highest point it is proposed to connect a bypass to a one million gallon reservoir in which the water level will be carried to an elevation of $2.309 \times 15 = 34.5$ ft. above the crest in the pipe line, and continue the pumping through the reservoir at the same rate with return of the water to the pipe line beyond the crest in place of pumping over the crest through the pipe line. Neglecting any differences of pipe friction introduced from bypassing, will more or less power be required to perform pumping at the normal rate?

R. A. C.

In each case, for pumpage at the normal rate, the pressure pumped against in the pipe line at the entrance to the bypass would be the same and delivery of the same quantity of water an hour would require the same power. But at any time when the back pressure from water in the reservoir would be greater than the pressure required in the crest to effect the same rate of discharge without bypassing, the power required for making the delivery through the reservoir would be greater. For instance, if the reservoir is filled, the pressure pumped against at the bypass would be 15 lb. per sq.in. regardless of the rate of delivery. But if the pressure required in the pipe line would be less because the same rate of delivery required less than 15 lb. per sq.in. for overcoming friction in the line beyond the crest, then pumping direct through the pipe line would require less power.

Replacing Gears on Oil Engine

It is necessary to replace the gears on the governor shaft of our 500-hp. vertical type Diesel. The new gears have no keyways. How is the correct position found? L. R. N.

It is necessary to have the camshaft in the proper position when setting the gears and the fuel pump must also be correctly set. In replacing the gears, the engine is first barred over until the crank of the No. 1 cylinder is 45 deg. ahead of upper dead center. This point can be found by setting off one-eighth of the circumference of the flywheel around the face from the dead center position. The fuel pump is a double-acting double-plunger pump and the vertical shaft must be set so that the plungers of the pumps that feed No. 1 and No. 4 engine cylinders are at the extreme inward points of their strokes. In this position the pump plunger has completed its working stroke. When the vertical shaft is moved so that the pump is in this position, the lower gear is marked for the keyway. As a check note the position of the upper keyway which, with the crank in the position stated, should face the compressor on left-hand engines and the flywheel on right-hand engines. The gear, after being marked, is removed and the keyway cut in a shaper or key slotter. With the keyway completed, the gear is replaced, care being used to see that the crankshaft has not been moved and that the fuel pump is still correctly placed.

The replacement of the top gear is along similar lines. The engine is barred over until the crank of No. 1 piston is 8 inches ahead of upper dead center on the compression stroke as measured on the flywheel rim. The cam levers controlling the fuel and starting cams are thrown into the running position and the servomotor screwed to its upper position. The various valve rocker arms should be adjusted to give the required roller clearances. The injection air valve is cracked to give around 300 lb. pressure. The camshaft is rotated until the air is barely heard to blow through the fuel valve. This locates the fuel injection point. The upper gear can now be marked for the keyway since the camshaft is in its proper relation to the engine crankshaft. In fitting these gears care should be taken to secure proper mesh of the teeth.

Shorter Cutoff, Greater Load

If indicator diagrams from a tandem compound engine show that more work is done in the low-pressure than in the high-pressure cylinder, what changes should be made to make the load balance? F. S.

The proportion of the total load carried by the low-pressure cylinder can be reduced by lengthening the low-pressure cutoff. A larger share of the work then will be done in the high-pressure cylinder on account of its reduced back pressure and the low-pressure cylinder will do less work on account of its reduced initial pressure.

Condensate Lost By Evaporation

When the condensate of steam pipes or coils containing steam at 110 lb. gage pressure is discharged by an intermittent trap to an open receiving tank, what percentage of water is lost from the hot water bursting into steam and escaping at atmospheric pressure? J. J. H.

Assuming that the condensate has the same temperature as steam at 110 lb. gage, each pound would contain 315.5 B.t.u. above 32 deg. F., and as the total heat of a pound of steam at atmospheric pressure is 1,150.4 B.t.u. above 32 deg. F., for conversion of a pound of the condensate to steam at atmospheric pressure it would have to receive 1,150.4 — 315.5 = 834.9 B.t.u. The heat so received would be obtained out of the water remaining in the receiving tank cooled from the initial temperature to 212 deg. F. and at atmospheric pressure. At atmospheric pressure each pound of the remaining water would contain 180 B.t.u. above 32 deg. F., so that each pound in cooling would be capable of supplying 315.5 — 180 = 135.5 B.t.u. Hence each pound evaporated would require the surplus heat of 834.9 ÷ 135.5 = 6.16 lb. of water, and therefore the condensate lost by evaporation would be $\frac{1}{6.16 + 1}$, or about 14 per cent of the total weight of condensate received by the trap.

Efficiency of Butt and Double-Strap Joint, Double-Riveted

What is the efficiency of a butt and double-strap joint, double-riveted, if the tensile strength of plate is 60,000 lb.; thickness of plate $\frac{15}{32}$ in., thickness of butt straps $\frac{3}{8}$ in., pitch of rivets in outer rows 5 in., diameter of rivet holes and of rivets after driving, $\frac{15}{16}$ in.? R. L. G.

The efficiency of the joint would be the least strength for a unit of pitch, P in the figure, divided by the strength of an equal length of solid plate.

Having a tensile strength of plate = 60,000 lb. per sq.in. of cross-section and thickness of plate $\frac{15}{32}$ in. = 0.46875 in.,

(1) The strength of solid plate per unit of pitch, P = 5 in., would be

$$5 \times 0.46875 \times 60{,}000 = 140{,}625 \text{ lb.}$$

With thickness of butt straps $\frac{3}{8}$ = 0.375 in., diameter of rivets $\frac{15}{16}$ = 0.9375 in. diameter, cross-sectional area of rivets = 0.9375 × 0.9375 × 0.7854 = 0.69 sq.in., and allowing strength of rivets in single shear = 44,000 lb. per sq.in. of cross-section, strength of rivets in double shear = 88,000 lb. per sq.in. of cross-section, and crushing strength of material 95,000 lb. per sq.in., the strength of the joint per unit of pitch P would depend on the least value obtained from the following considerations:

(2) Strength of plate between rivet holes in the outer rows =

$$(5 - 0.9375)0.46875 \times 60{,}000 = 114{,}257 \text{ lb.}$$

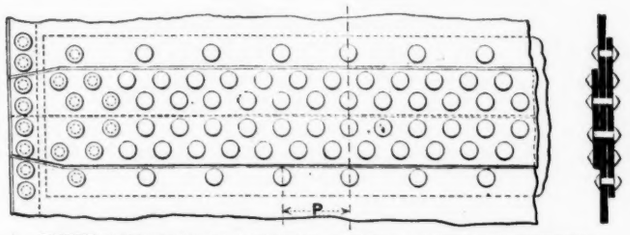
(3) Shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear =

$$2 \times 88{,}000 \times 0.69 + 1 \times 44{,}000 \times 0.69 = 121{,}440 \text{ lb.}$$

(4) Strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row =

$$(5 - 2 \times 0.9375)0.46875 \times 60{,}000 + 1 \times 44{,}000 \times 0.69 = 118{,}250 \text{ lb.}$$

(5) Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row =



BUTT AND DOUBLE-STRIP JOINT, DOUBLE-RIVETED

$$(5 - 2 \times 0.9375)0.46875 \times 60{,}000 + 0.9375 \times 0.375 \times 95{,}000 = 121{,}288 \text{ lb.}$$

(6) Crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet =

$$2 \times 0.9375 \times 0.48675 \times 95{,}000 + 1 \times 0.9375 \times 0.375 \times 95{,}000 = 116{,}894 \text{ lb.}$$

(7) Crushing strength of plate in front of two rivets, plus the shearing strength of one rivet in single shear =

$$2 \times 0.9375 \times 0.46875 \times 95{,}000 + 1 \times 44{,}000 \times 0.69 = 113{,}856 \text{ lb.}$$

The least strength would be obtained from consideration (7), namely 113,856 lb. per unit of pitch, and the efficiency of the joint is 113,856 ÷ 140,625 = 0.8096, or practically 81 per cent.

Reduction of Theoretical Suction Lift

Why cannot a pump raise water by suction lift through the height of a column of water that would be balanced by the pressure of the atmosphere? R. L. G.

To lift water by suction to the same height as a column of water supported by the pressure of the atmosphere would require a perfect vacuum. That is not possible to attain on account of air leakages through the stuffing box and joints of the pump connections. and also because the water boils before all pressure is removed and the space above the water becomes filled with vapors and air liberated out of the water. In addition to the counter-pressure thus introduced, for continuous flow, part of the atmospheric pressure is required for overcoming the frictional resistance to the passage of the water through the foot valve, suction pipe, fittings and passages to the pump suction chamber.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Application of Automatic Combustion Control to Mechanical Stokers*

By Charles H. Smoot†

In so far as the mechanism for feeding in coal, distributing it over the grate and removing the ash is concerned, the American stoker manufacturing art is in excellent shape. Under test-run conditions, where experienced help is available for controlling the supply of fuel and air, the efficiencies obtained from stokers leaves little to be desired, and higher boiler economies could hardly be expected from further improvements in stoker mechanism. Further increases in efficiency lie elsewhere than in the stoker. The boilers themselves, with or without economizers, must be depended on to reduce the temperature to a minimum and convert the water to steam by the furnace heat generated.

The boiler is supplied with a given available heat in the fuel, and this heat is in great part recovered in the steam. A portion escapes as sensible heat with the flue gases, and a smaller portion is found as unburned carbon in the ash. The percentage of carbon so wasted is on an average small, and no material improvement can be anticipated by further reducing this loss. The saving of sensible heat loss to the stack is not a problem for the stoker, but for the boiler and plant design as a whole.

In spite of this there are few boiler plants whose average performance is within 10 per cent of test-run conditions and the great majority are run with an efficiency more than 20 per cent under test-run conditions. The majority of boilers and stokers are capable of approximating 80 per cent efficiency, but comparatively few reach 70 per cent in actual practice.

Why Test Runs and Commercial Operation Differ

The principal cause of the difference between test-run and commercial operation is a lack of balance between fuel and air supply to the combustion space. It is practically impossible in most plants to operate an underfeed stoker with a flue-gas analysis which will average better than 10 or 12 per cent CO_2 without at the same time having periods during which the flue gas contains appreciable quantities of CO. On the other hand, when a fire is correctly regulated in any reasonable boiler setting, it may be kept continuously operating at 14 to 15 per cent CO_2 flue gas on bituminous coal and 16 to 17 per cent flue gas on anthracite, and with no CO present.

The problem of combustion regulation is a matter quite foreign to the design of a stoker. The stoker mechanism feeds in the coal and spreads it over the grate, and when the mechanism is such as to do this in a uniform and continuous manner, it has fulfilled its mission. The conditions governing the fireman's work are such that it is almost impossible for him, even with the best intentions, to maintain the fire and supply of air and fuel at their proper relative proportions all the time.

There comes to mind a plant burning an aggregate of one and a half million dollars worth of coal a year in a battery of 28 boilers. The money spent by this company is converted to coal and the coal is delivered to the firemen to expend as they please, with little or no supervision and little or no opportunity for controlling the method in which they spend this one and a half million dollars. From a purely financial point of view the situation is grotesque.

In the same plant an average yearly economy of 65 per cent is a good performance under present conditions. The load factor on this plant is good, and if the boilers all performed with the efficiency of test-run conditions, the yearly average efficiency of the boiler plant would be above 74 per cent. In other words, this plant is losing the money difference between the two efficiencies, a loss of approximately $200,000 a year, due to lack of properly proportioning the supply of fuel and air.

It is manifestly impossible for a stoker mechanism to govern the supply of air and fuel, but it is possible for governing mechanism in addition to the stoker to accomplish this result.

Efficient combustion in a boiler is distinctly a chemical process. There is just one mixture giving maximum efficiency for any given setting, character of fuel, etc. Any other ratio of fuel to air gives a somewhat less efficiency. A variation of 10 per cent is not a serious matter, but with hand control the variations are far in excess of 10 per cent, and usually the commercial plant is run with a large excess of air, wasting its quota of heat up the stack.

When burning powdered fuel, it is far easier to control the fuel and air mixture and the flue-gas analysis for uniformity by hand than to control the underfeed stoker, and for the reason that powdered fuel, oil and gas are burned as they are supplied, permitting the firemen to detect immediately an error in ratio of fuel to air supply. On the other hand, the underfeed stoker does not burn immediately the fuel supplied, and in fact at any given instant the rate of fuel combustion is dependent on a number of complicated factors which are totally beyond the fireman's comprehension. These factors comprise the temperature of the fuel bed, the thickness of the fuel bed and the rate of air supply.

In the case of powdered fuel, oil and gas a change in ratio of fuel to air supply immediately registers a change in the appearance of the fire. With the underfeed stoker the change is not immediately apparent, and in fact the fireman can only tell, when too much or too little coal is being fed to the furnace, an hour or two after he has made the adjustments. I ascribe to this difficulty of regulation the greater part of the difference in observed economy between underfeed stokers and oil, gas or pulverized-fuel fires.

When, however, the rate of fuel and air supply is regulated at all times to produce the correct mixture, there should be but little difference in economy between the underfeed stoker and the pulverized-fuel, oil- or gas-fired boiler.

Regulation of Mixture Important

While the need for automatic regulation in control of powdered fuel may not be as great as for the mechanical stoker, nevertheless the regulation of mixture in the powdered-fuel furnace is a matter of extreme importance, since it is this mixture which controls the maximum temperature. The powdered-fuel fired boiler should run with the highest possible combustion-chamber temperature which the brickwork will permit, and one of the duties of automatic regulation in the supply of fuel and air is to assist in maintaining this temperature.

Stokers have been developed to a high state of perfection. It is seldom, however, that they are judged on their merits, and it is the rule that the stoker performance is judged very largely by the skill of the fireman who happens to be tending the equipment rather than by the intrinsic merit of the stoker itself. Perfection of the stoker can be completely overshadowed by incompetent or indifferent firemen.

To fire a boiler properly with stokers or any other equipment is more of an art than a science, and just as long as it is left an art and not a science, just so long will the results be a matter of temperament and lack certainty of result. Firemen are poorly paid men, engaged in unpleasant, dirty, rough work. In order that they may obtain the best results from mechanical stokers, they should be educated men, understanding the theory, science and practice of combustion, and at the same time work for the price of a laborer and do laborer's work. It is a hopelessly paradoxical condition.

An answer to the paradox is to provide sufficient centralized indicating and regulating apparatus to permit the boiler-room chief, while seated comfortably at a desk in front of an instrument board, to control the money expenditure in the boiler plant. He, of course, is supplemented with men who do the heavy and arduous work always found in a boiler room. This one man, however, is in charge of the combustion control and is the man who is spending the money value in the coal, which he is enabled to do with this apparatus in an efficient manner.

*Abstract of paper presented at the American Stoker Manufacturers Association's Convention, Lake Placid, N. Y., May 31, 1923.

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Proper Length of Evaporating Coil*

By C. H. HERTER

OPINIONS as to the proper length of cooling coil to be connected to one ammonia expansion or feed valve differ widely. Otto Luhr, in his "Mechanical and Refrigerating Engineer's Hand Book," 1913, states that experience has shown that the most satifactory results are obtained when the length of 2-in. coil for direct-expansion ammonia does not exceed 5,000 to 6,000 ft. He advocates long coils, and of a number that will not exceed in cross-sectional area that of the suction pipe leading to the compressor. For example, to a 50-ton machine having a 3-in. suction pipe, he would connect a total of 15,000 lin.ft. of 2-in. pipe, arranged in but three coils. Incidentally, it will be found that with gravity air circulation the temperature difference between room air and pipe in his case would equal

$$\frac{50\ (tons\ refrig.) \times 12{,}000\ (B.t.u.)}{15{,}000\ (ft.) \times 0.6218\ (sq.ft.) \times 2.95\ (B.t.u.)} = 31.4\ deg.\ F.$$

Another refrigeration pioneer, Eugene T. Skinkle, stated in *Practical Ice Making and Refrigerating*, that for direct expansion there seemed to be no particular established length of coils. A variance of from 800 to 2,000 ft. to the coil was noted, and even at the latter figure he thought that the limit had not been reached.

Oswald Gueth, author of "The Refrigerating Engineer's Pocket Manual," 1908, cautions the reader as follows: "'No more than 1,200 ft. of 2-in. pipe should be used on one expansion valve."

In these days of standardization one is not convinced that coil lengths of 800 and of 600 ft. of 2-in. pipe will be equally efficient. As the result of investigation engineers are abandoning many other rules of thumb, including the old tables of ratio of cubic feet of refrigerator space per foot of pipe, and it is time that an effort be made to determine the factors that govern the proper length of heat-absorbing pipe per feed valve.

Behavior of Fluid Within the Pipe

To solve the problem along logical lines, it is well to bear in mind that the refrigerating effect of pipe surface is due to the latent heat of evaporation of the liquid within the pipe. Cooling pipes in a room act as ammonia boilers, and any portion of the piping not actively boiling off ammonia is not doing its share of the work. Since the air temperature in the refrigerator is practically the same throughout the length of the coil, its ability to abstract heat from the surroundings depends chiefly upon the conditions existing within the coil.

Suppose liquid ammonia at a temperature of 86 deg. F. and under a gage pressure of 154.5 lb. per sq.in., reaches the expansion or feed valve. Since the valve is but slightly open, throttling the flow of liquid, the pressure at the coil side of the valve may be 15.7 lb. gage, resulting in an evaporating temperature of 0 deg. F. Owing to the continued pumping of the compressor at the end of the suction pipe and to the careful regulation of the fuel valve the evaporating pressure within the refrigerating piping is maintained nearly uniform.

The latent heat of evaporation of one lb. of ammonia at 0 deg. F. is 568.9 B.t.u. The cooling effect, however, is not realized to this extent, because a portion of this heat has to be sacrificed for first lowering the temperature of the warm liquid. The heat content of liquid at 86 deg. is 138.9 B.t.u. per lb. and at 0 deg., 42.9 B.t.u. The difference, or 96 B.t.u., must be deducted from 568.9 B.t.u., leaving a net useful refrigerating effect of 472.9 B.t.u. per lb., *provided* the pound just evaporates completely to vapor at 0 deg. If, for example, only 95 per cent of the liquid evaporates in this coil, then the useful cooling effect per lb. circulated is only 0.95 × 472.9, or 449.25 B.t.u.

If a cooling coil is rather short, the vapor is likely to leave it in a "wet" condition, but the insertion of a liquid separator into the suction main of the compressor prevents any loss due to unevaporated liquid if this liquid is returned to the cooling pipes, so that nothing but dry saturated or very slightly superheated gas returns to the compressor. Actual experience has demonstrated that, per square foot of cooling surface, a well-wetted coil is much more efficient as a heat absorber than a coil partly dry.

The situation in a very long coil is this, that the inlet portion may be freely supplied with liquid and is doing work proportional to its temperature. After there is no more liquid to evaporate, the gas in the pipe will become "superheated"; that is, its temperature will be higher than it should be according to its pressure. Its saturation temperature at 15.7 lb. gage pressure is 0 deg.. and if the cold-storage room temperature is 30 deg., the gas is in position actually to take up heat corresponding to 30 deg. of superheat. The specific heat of the gas being about 0.57 in this region, each pound can absorb 30 deg. × 0.57, or 17.1 B.t.u., after having already absorbed, in the wet portion of the coil, 472.9 B.t.u., making a total cooling effect of 490 B.t.u.

This looks like a gain for the coil, but it is only 3.6 per cent, and the tail end or superheat portion of the coil has a very low efficiency per square foot, because here the temperature difference between room air and pipe averages 15 deg. instead of 30. By the time this gas reaches the compressor, it is likely to be at 50 deg. F. and occupies a space of 10.3 cu.ft. per lb. against 9.2 cu.ft. at 0 deg., thus reducing the output of the compressor by fully 10 per cent. In fact, the loss in inactive capacity is ever greater because of the expansion of the gas when coming in contact with the hot walls of the compressor.

These considerations prove that instead of an advantage there is a loss in keeping the vapor too long within the coil, and that the only gain possible is with coils freely wetted with liquid throughout their full length.

Pressure Drop an Important Factor

Another feature that has a decided bearing on the profitable length of coil per feed valve is the extent of pressure drop during the travel from inlet to outlet. Since, as a rule, the gage indicates only the pressure prevailing in the suction pipe near the compressor, it is erroneously assumed that this pressure is constant throughout the low-pressure side. It stands to reason that near the entry of the cooling coil the pressure must be one or more pounds higher than at the inlet to the machine where the gas is continually being pumped away, and because without pressure difference there can be no flow. To determine the extent of this pressure drop, it would be necessary to use accurate large dial gages and thermometers at both inlet and outlet of a cooling coil.

Until such experimental proof is forthcoming, we have to confine ourselves to a calculated estimate of the resistance to be overcome by the vapor in forcing its way at high velocity through the zigzag cooling coil.

Taking, for example, Mr. Luhr's favorate length of a 2-in. cooling coil, 5,000 lin.ft., at a gage pressure of 15.7 lb. (0. deg. F.), assume that for every 50 ft. there is one 180-deg. return bend or two elbows. According to Kent's Handbook the friction through these 100 return bends is equal to at least 1,000 ft. of pipe.

By Martin's formula, given in Lucke's "Engineering Thermodynamics," the loss in pressure due to pipe friction is as follows:

$$(p_2 - p_1) = 0.0003133 = \frac{w^2 \times L}{D \times d^5}$$

where w = pounds fluid per minute, L = equivalent length of pipe in feet, D = density of fluid in pounds per cubic foot, and d = inside drain of pipe, in inches.

*Paper read before the spring meeting, American Society of Refrigerating Engineers, St. Louis, Mo., May 5, 1923.

By a previous calculation it was found that at 86 and 0 deg. the useful refrigerating effect per pound of ammonia evaporated was 472.0 B.t.u. The quantity required per minute per ton refrigeration is 200 ÷ 472.9 = 0.423 lb. As the coil in question is to do 16.67 tons refrigeration, it has to evaporate 16.67 × 0.423 = 7.05 lb. of liquid per minute. Hence $W^2 = 7.05^2 = 49.7$. The density of the saturated vapor at 0 deg. is 0.1097. For a pipe diameter of 2 in., $2^5 = 32$. The pressure drop within this coil, if it did perform as stated, would figure out to 26.62 lb. per sq.in., giving a gage pressure at the expansion valve of 15.7 + 26.62 = 42.32 lb., and a temperature of 28.8 deg. F. It is now evident that the mean coil temperature is 14.4 deg., not 0 deg., and that the temperature difference is but two-thirds as great as assumed, hence the heat absorbed also is correspondingly less, necessitating a correction in our estimate. Now 5,000 × 0.6218 × 2.05 × 20 deg. = 127,400 B.t.u. per hour, which, divided by 12,000, equals 10.61 tons. At a mean coil temperature of 10 deg. F. the pressure drop appears to be

$$0.000313 \frac{4.49^2 \times 6{,}000 \ ft.}{0.1369 \times 32} = 8.65 \ lb.$$

Lacking space for further trials, it may be concluded that this particular long coil is capable of 9 to 12 tons of work with a pressure loss within the coil of 7 to 9 lb., but it will be admitted that this performance is far from satisfactory.

Suppose we make this 2-in. coil only one-fourth as long, or 1,250 ft. The equivalent of 25 return bends is 250 ft. more straight pipe, giving a total of 1,500 feet.

The heat removed, by 1,250 ft. of 2-in. expansion pipe at 30 deg. difference between cold room and pipe is 1,250 ft. × 0.6218 × 2.05 × 30 deg. = 47,800 B.t.u. per hour, or 3.98 tons. At 0 deg. this requires the evaporation of 3.98 × 0.423 = 1.685 lb. liquid per minute. In this case the pressure drop is equal to only 0.38 lb., a result indicating good practice.

Let us now examine a coil of 1¼-in. extra-strong pipe (weight 3 lb. per lin.ft.) 100 ft. long. At 20 deg. mean temperature difference this coil should absorb heat at the rate of 1,000 ft. × 0.4346 × 2.15 × 20 deg. = 18,700 B.t.u. per hour, or a rate of 1.558 tons of refrigeration.

One return bend for every 20 ft. equals 50 bends, equivalent to 250 ft. of straight pipe. The friction loss is therefore, that due to 1,250 feet.

Assuming 10 deg. evaporating temperature we find a pressure drop within this coil of

$$0.0003133 \frac{0.659^2 \times 1{,}250 \ ft.}{0.1369 \times 3.05} = 0.407 \ lb.$$

This performance is acceptable. Suppose, however, that the same coil is operated at 0 deg. in a room at 40 deg. It should then do 3.116 tons of refrigeration. The pressure drop suffered would be

$$0.0003133 \frac{1.317^2 \times 1{,}250 \ ft.}{0.1097 \times 3.05} = 2.03 \ lb.$$

Evidently, we have gone too far and the coil, at 40 deg. difference, had better be kept down to about 600 ft. effective length.

Suppose we place a 600-ft. long 1¼-in. coil into an ice-making tank where the vapor temperature is 0 deg. and the brine 15 deg. and the rate of heat transfer 15 B.t.u. per sq.ft. Including the bends the resistance is that due to 750 ft. The work of this coil amounts to 600 × 0.4346 × 15 × 15 = 58,700 B.t.u. per hour, or 4.89 tons of refrigeration. The pressure drop encountered equals

$$0.0003133 \frac{2.07^2 \times 750 \ ft.}{0.1097 \times 3.06} = 3 \ lb.$$

This coil had better be made only 400 ft. long, because a pressure drop of 3 lb. means that the compressor has to operate at 3 lb. lower pressure than the mean pressure within the coil, and that causes loss in capacity and increased power consumption per ton. In a large New York ice plant the actual coil length exceeds 800 ft. and the consumption of current is over 10 kw.-hr. higher per ton of ice made than it should be.

From the foregoing calculations it is apparent that no arbitrary length can be pronounced as being the ideal one for any pipe diameter regardless of evaporation rate. The more vapor formed per minute per foot of pipe the shorter must be the coil, otherwise an unduly high vapor velocity will be reached, a difference in pressure created within the coil, and a wide variation obtained in pipe temperature. But with enough patience one can determine reasonably correct lengths of coils for certain frequently occurring sets of conditions.

The following data may be helpful in this connection.

The quantity of liquid ammonia required per minute per ton of refrigerating effect, arrived at as computed above, varies from 0.4 to 0.45 lb. over an extremely wide range of temperatures.

Cooling Capacity of Pipes

The rate of heat transfer from ordinary unagitated air to a dry pipe surface at 20 to 40 deg. F. temperature difference varies with the pipe diameter as follows, according to R. H. Heilman, Mellon Institute of Industrial Research:

Pipe size, inch	½	¾	1	1¼	1½	2
K, B.t.u.	2.40	2.30	2.20	2.15	2.10	2.05

On the basis of these figures the heat absorbed per 1,000 lin.ft. of air-cooling pipe at the temperature differences indicated is as follows, in B.t.u. per hour:

TABLE I—HEAT ABSORPTION PER 1,000 FT. OF COIL

Pipe size	½	¾	1	1¼	1½	2
Sq.ft. ext. surface per 1,000 lin.ft.	219.8	275	344.3	456.6	497.4	621.8
B.t.u. at 10 deg. dif.	5,280	6,320	7,570	9,340	10,440	12,750
B.t.u. at 20 deg. dif.	10,560	12,640	15,140	18,680	20,880	25,500
B.t.u. at 30 deg. dif.	15,840	18,960	22,710	28,020	31,320	38,250
B.t.u. at 40 deg. dif	21,120	25,280	30,280	37,360	41,760	51,000
B.t.u. at 50 deg. dif.	26,400	31,600	37,850	46,700	52,200	63,750

TABLE II—RATE OF FORMATION OF VAPOR*

		—Per Hour— Pounds	Cu.Ft.	Per Min. Cu.Ft.
At 10 deg. dif.	9,340 ÷ 472.9 =	19.74	180	3
At 20 deg. dif.	18,680 ÷ 472.9 =	39.48	360	6
At 30 deg. dif.	28,020 ÷ 472.9 =	59.22	540	9
At 40 deg. dif.	37,360 ÷ 472.9 =	78.96	720	12
At 50 deg. dif.	46,700 ÷ 472.9 =	98.70	900	15

*Lb. liquid ammonia evaporated by 1,000 lin.ft of 1¼-in. pipe, assuming complete evaporation at 0 deg. F., and volume of saturated vapor resulting (9.116 cu. ft. per lb.)

The sectional area of 1¼-in. extra-strong pipe should be 0.00883 sq.ft. Dividing the volume of vapor found in Table II by this area, the resulting exit velocity (for saturated vapor) from the 1,000 ft. long coil is found to be:

At 10 deg. dif.	3 cu.ft. ÷ 0.00883	=	340 ft. per min.
20	6		680
30	9		1,020
40	12		1,360
50	15		1,700

Above 30 deg. difference between pipe and air, superheated vapor will be formed, giving still higher velocities, consequently 1,000 ft. per min. seems to be the limit for proper operation. It was found that at 40 deg difference there was a pressure drop of 2.03 lb., and it will be seen that this is associated with an exit vapor velocity of 1,360 ft. per min. This applies to a coil of 1¼-in. pipe 1,000 ft. long. Similar tables and preferably curves can be prepared for other heat-transfer rates and for other pipe sizes and coil lengths, the object being to keep the pressure drop down to one pound.

Velocities of 1,000 ft. per min. may appear as very conservative to those who are not concerned in pressure drops and who would make the coil velocity equal to that in the suction pipe (3,000 ft. or more per min.), but when it is considered that we are actually dealing with a mixture of liquid and vapor and that velocities of liquids are better kept down to one-tenth of the speed of the vapor, the justification for low ammonia velocities becomes apparent.

Many are of the opinion that high velocity inside the pipe promotes the transfer of heat, but the pressure drop imposes a limit. However, in the case of room piping the heat conduction from fluid to inside wall of pipe is so much greater (100 to 400 B.t.u. hour, sq.ft. deg.) than the rate of heat exchange at the outside (1 to 2 B.t.u. hour, sq.ft. deg.) that no real advantage results from high vapor velocity.

The only rational improvement that can be made is to pre-

cool the liquid, abstracting the sensible heat in an accumulator, and allow the vapor resulting from this liquid cooling to return immediately to the compressor, thereby relieving the cooling coils proper from about 17 per cent of useless vapor. This is being done in up-to-date freezing tanks. When coupled with a high rate of brine agitation, this feature yields an over-all heat transfer rate of 20 to 30 B.t.u. per sq.ft. per hour per deg. difference in such brine-cooling coils, as against one-third these rates in old-style tanks.

Conclusions

For efficient operation enough liquid should be supplied that even the last foot of coil receives its quota. Unless the exit vapor velocity is kept below 1,000 ft. per min., this condition will not obtain and the tail portion of the coil will be almost useless. Accordingly, a consulting engineer who merely specifies *quantity* of piping without regard to quality in piping, is not guarding the best interests of his client, because manufacturers may give him the first, but not the second, for fear they may lose the order. The omission of a few expansion valves may reduce the initial cost $100, but the user will each year pay several times this amount in higher operating expense.

Heating with Condenser Circulating Water*

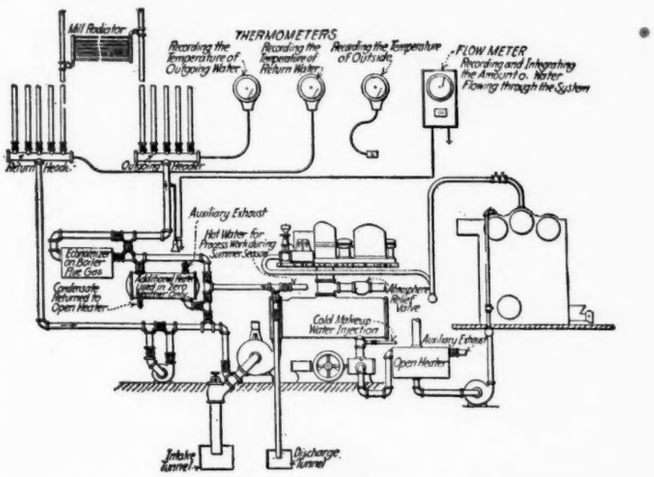
By John E. Williams†

Heating under partial vacuum has not received the attention that it deserves. Twenty-five years ago, at the Chase Rolling Mills a heater was set up between a 48-in. low-pressure cylinder and the jet condenser and was connected to a forced-feed hot-water heating system containing 50,000 sq.ft. of radiation. When heating was first called for in the fall, 50,000 gal. of water per hour was circulated through the heater and the exhaust steam from the engine gradually heated it up to the temperature corresponding to a vacuum of 23 in. When the water reached this temperature, it was possible to operate at a vacuum of 26 in. and still supply sufficient heat to maintain the buildings at the desired temperature. As the weather grew colder, the water was cut down on the jet condenser, lowering the vacuum, but giving a higher temperature to meet the weather requirements. This plan was continued until the vacuum was reduced to 20 in., at which point only a small amount of injection water was used, for the heater had become practically a surface condenser and the jet condenser a wet vacuum pump. To supply the same amount of power under the lower vacuum, the engine cut off later, but this did not lower the over-all economy, as all the heat in the steam that was not utilized was returned to the boiler or used in manufacturing processes.

After the water in the heating system left the heater, it passed through an economizer. Assuming that the water leaving the heater was at a temperature of 158 deg. F., corresponding to 20 in. of vacuum, the economizer stepped up the temperature to 166 deg., which was sufficient to meet an outdoor temperature of 16 deg. above zero, with a radiation ratio of 60 to 1. For the short time that the weather in this locality was below 16 deg., the extra heat was supplied by a steam compressor or a small steam engine exhausting into a second heater connected into the system rather than to reduce the vacuum on the main unit below 20 inches.

At the same mill another system with 110,000 sq.ft. of radiation is operated through a range from 6 in. to 26 in. of vacuum to care for the heating requirements. Originally, a high-pressure engine with a cylinder 16 in. in diameter exhausted into the heater of this system under a back pressure of about one pound. The heat could be regulated only by taking off or putting on more load; in other words, the flexibility of the partial vacuum system was missing and the amount of power developed was less than it should be. As a consequence a 500-hp. cross-compound engine with the same size of high-pressure cylinder, calling for the same amount of steam, supplanted the simple engine. The compound engine was connected up to operate on the partial-vacuum principle, and instead of 35,000 kw.-hr. a week, the new unit developed from 60,000 to 70,000.

Twelve years ago, when the Chase Metal Works was being erected, a turbine was installed as prime mover and was tied in with the same kind of open forced-feed hot-water system that had given such excellent results for the fifteen years previous. The illustration shows the turbine installation, which is rated at 600 kw., and the connections to the heating system. Through an expansion joint and distance piece the turbine is connected to a surface condenser. Underneath the condenser is a wet air pump of large capacity, and it will be noticed that the circulating pump may



ARRANGEMENT OF HEATING SYSTEM FOR CHASE METAL WORKS

draw water from the cold intake well when no heating is required and the turbine is operating under 28 in. of vacuum.

When the heating system is on, the intake from the tunnel is shut off and the water in the heating system circulated through the condenser. As the water heats up, the vacuum drops to 26 in. if the unit continues to carry 600 kw. It will be assumed that the heating medium at a temperature corresponding to 26 in. of vacuum will meet the requirements imposed by an outdoor temperature of 50 deg. and that it is desired to hold the vacuum at this point and maintain a temperature of about 120 deg. on the coils. This is done in two ways, either by putting some of the 600-kw. load on the other generating units or by running some cold injection water into the wet air pump. As this water is used for boiler makeup, there is no loss. As the weather grows colder, the amount of injection water is reduced to meet the requirements. It should be borne in mind that the wet vacuum pump becomes a jet condenser when water is forced into it to maintain the vacuum and that it should have sufficient capacity to meet the requirements. With an outdoor temperature of 20 deg. it was found that the injection water could be shut off and a larger load thrown on the turbine to meet the demands imposed by the colder weather.

In the past we have adopted the expediency of dividing the heating system, leaving 130,000 of the total 178,000 sq.ft. of radiation on the one turbine to balance the load during cold weather and throwing the other 48,000 sq.ft. of radiation serving the office and other buildings on another unit. As the latter buildings require a temperature of 70 deg., as compared to 60 deg. in the remainder of the works, this arrangement contributes to the economy of the system in much the same way as increasing the radiation to permit a lower temperature of the heating medium and a higher vacuum.

As in the other systems previously mentioned, the heating water also passes through an economizer, and during the colder weather a little exhaust from the steam auxiliaries is turned into the heater in preference to lowering the vacuum.

*Abstract of paper presented before semi-annual meeting of the American Society of Heating and Ventilating Engineers, Chicago, May 21-23, 1923.

†Chief engineer, Chase Metal Works, Waterbury, Conn.

In meeting all weather conditions the partial-vacuum principle of heating is flexible. Nothing special is required in equipment to care for the heating feature, but the jet or wet vacuum pump should be of a type that would act as a check; in other words, it should be an open-valve pump set below the condenser, so that if a tube ruptures when the equipment is shut down, the water can run straight through. For high buildings the body of the condenser should be designed to meet the static head. In our case we carry a pressure of 40 lb. on ordinary condensers.

Manipulation of the system is simpler than heating with exhaust steam at or near atmospheric pressure in the usual way. In connection with his other work, the oiler in our plant cares for the heating system. He first consults the outdoor recording thermometer and then looks at the chart giving the corresponding temperature that should be maintained on the heating system. On his rounds he consults the temperature of the outgoing water. This may be adjusted according to requirements by increasing or decreasing the load on the generating units or by putting more or less cold water into the condensate pump. The big advantage of the system is that both power and heating requirements are met and the gain is the extra power obtained through the vacuum carried over non-condensing operation at a definite back pressure.

New England States Section of the N.A.S.E. Holds Convention

The annual convention of the New England States Association of the National Association of Stationary Engineers was held at Manchester, N. H., July 12, 13 and 14. The Manchester Hotel was the official headquarters, but owing to the lack of space many of the delegates and guests found it necessary to take up quarters in the other hotels of the city.

The sessions of the delegates were held in the Carpenter's Memorial Library Hall. There were seventy-two delegates present, and several important resolutions were brought before the body for discussion and consideration. One of the principal measures adopted was the discontinuance of past methods relative to the yearly meetings. It was decided that the business of future conventions shall be conducted solely by the officers of the N.A.S.E., which includes all arrangements for the mechanical exhibition.

The main hall in the LeChateau, on Lowell Street, was appropriately decorated and conveniently arranged in booths for the use of the Supplymen in the display of mechanical devices and power-plant equipment. The spaces were occupied by sixty firms in the engineering field, and the exhibit was fairly well patronized.

On Thursday evening at eight o'clock the official opening of the exhibition took place. Daniel L. Smith, chairman of the local committee, presided. Mr. Smith thanked the delegates for the big attendance and praised the supplymen for the great display. He was grateful to the Chamber of Commerce and other city officials for their help toward the success of the convention. Arthur Finney, city clerk, representing the Mayor, extended the hospitality of the city to the visitors. President James H. Henderson responded for the engineers and guests. Charles H. Toby, president of the Chamber of Commerce, dwelt on the valuable commercial and industrial interests of the city. He also told of the rare beauties of Manchester and hoped that the N.A.S.E. would call soon again. Past National President P. H. Hogan thanked the speakers for their generous welcome and assured them that the visit would prove of mutual interest.

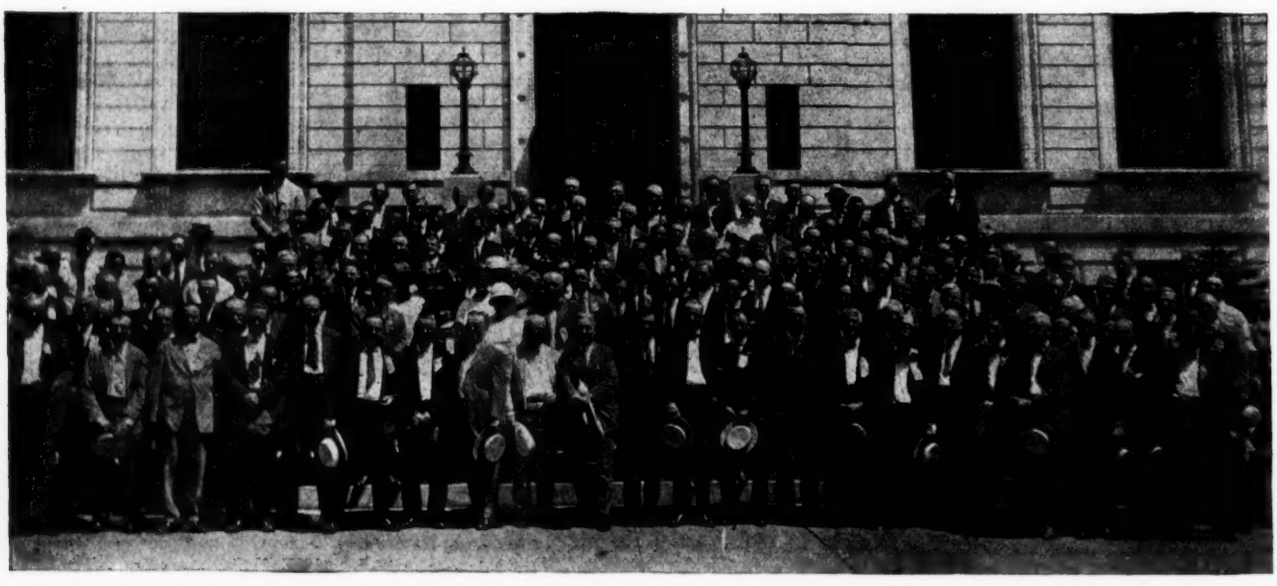
At the opening session of the delegates on Friday morning an unusually interesting paper, describing the power plants of the Amoskeag Manufacturing Co., was read by Water G. Diman, superintendent of power. Mr. Diman was the recipient of warm congratulations and a hearty vote of thanks.

On Friday evening, in the exhibition hall, an enjoyable entertainment was held. Those participating included Bob Jones, of the Magic Boiler Preservative Co.; Joe McKenna, of Jenkins Bros.; James Donnelly, of the Gulf Refining Co., and Jack Armour, of *Power*. At the close of the entertainment National Trustee W. J. Reynolds, after a brief address, presented William H. Henderson a past president's jewel and a handsome silver service. Mrs. Henderson was given a costly umbrella.

The New England States Association at its closing meeting elected the following officers: Edwin H. Perry, president, Worcester, Mass.; Daniel L. Smith, vice-president, Manchester, N. H.; Freeman L. Tyler, secretary, Taunton, Mass.; Walter H. Damon, treasurer, Springfield, Mass.; O. A. Buma, conductor, Worcester, Mass.; T. H. Golden, doorkeeper, Providence, R. I.

The next convention will be held at Cambridge, Mass., in July, 1924.

In the July issue of *Industrial & Engineering Chemistry* Prof. R. T. Haslam, of the Massachusetts Institute of Technology, gave the results of an investigation into the simultaneous combustion of hydrogen and carbon monoxide. In this he showed that where the two gases are mixed, the hydrogen burns 2.86 times as rapidly as the carbon monoxide. From this the conclusion was drawn that for a gas-fired boiler an increase in the percentage of hydrogen might make it possible to obtain satisfactory results with a furnace that would otherwise be too small.



DELEGATES, SUPPLYMEN AND GUESTS AT THE CONVENTION OF THE NEW ENGLAND STATES ASSOCIATION, N.A.S.E.

News in the Field of Power

New York State Water Power Commission Reports to Governor

Future of Water Power in State's Own Hands with Aid from Federal Government if Proper Legislation Is Enacted, Say State's Officials

NEW YORK STATE is in a position today to develop its inland and border water powers and it should not adopt an obstructive attitude toward this end either by refusing to develop them itself or by refusing to allow someone else to do it, is the opinion of Attorney-General Carl Sherman, State Engineer Dwight B. La Du, Deputy Attorney-General Edward G. Griffin, Charles A. Collins and John Godfrey Saxe, expressed in their report on the status of the state's action against the federal government to test the constitutionality of the Federal Water Power Act.

Conferences in Washington by this committee and Hubert Work, Secretary of the Interior, Henry C. Wallace, Secretary of Agriculture, and O. C. Merrill, William Kelly, Major Lewis W. Call and J. F. Lawson of the Federal Power Commission, resulted in the following recommendations to Governor Smith by the New York State Water Power Commission:

1. That we do not commence the taking of testimony in the present suit at the present time, but with the permission of the United States Supreme Court, permit the suit to stand along for the present, unless and until the Federal Power Commission should change its present conciliatory position.

2. That the State of New York, at the earliest possible moment, enact the statute for state development, recommended in your message of March 5, 1923 (the Rabenold-Hackenburg bill), so that the rights of New York may not be jeopardized and the development of its water power delayed because of the absence of such a statute.

3. That the State Water Power Commission continue in close touch with the Federal Power Commission and endeavor to harmonize from time to time, any conflicting claims which may arise, to the end that the development of the water-power resources of the state may be accelerated.

4. That during the coming session of Congress federal bills relating to water power be carefully scrutinized and that the state be represented at any and all committee hearings in respect to any measures which may affect the rights of New York.

In part the report says:

For all practical purposes in the immediate future, the pending suit against the federal officials has accomplished the objects for which it was brought. The acceptance by the defendants, in their answer of the leading propositions constituting the basis of the complaint, and the full and frank confirmation thereof at this conference between the representatives of the federal and state commissions, have apparently settled the principal propositions for which the State of New York has contended, and which the Federal Power Commission had previously seemed unwilling to accept.

The disavowal by the Federal Power Commission of any intention to interfere with power developments in connection with the Barge Canal, and the expressing of willingness to co-operate with the state and the International Joint Commission in state development of the power possibilities of the Niagara and St. Lawrence Rivers, without claiming a proprietary right on the part of the federal government to share in profits therefrom, has now cleared the way, so far as the federal government is concerned, for power developments on these boundary streams by virtue of the concerted action of the state, the Federal Power Commission and the International Joint Commission.

We fully concur in Your Excellency's message to the Legislature, dated March 5, 1923, that New York's water power must be developed in accordance with the enlightened thought of today, by the state itself, under state ownership and state control, to the end that all of the people may be able to realize the individual benefit which should flow to them from their resources and their own property.

This would mean the immediate development by the state of the undeveloped water power available on the Niagara and St. Lawrence. We believe that the absence of such a statute jeopardizes the rights of the state in its relations with the federal government.

Export Coal Situation

The United States has exported for the five months, Jan.-June, 1923, according to the report of the Federal Fuel Director, 8,705,572 tons of coal and 611,306 tons of coke. This is a large increase over the figures for the same period for 1922. Of this, 1,624,745 tons of bituminous and 308,842 tons of coke have gone overseas and, although not included in the report of the Federal Fuel Director, there is reported to have been 445,813 tons of anthracite sent overseas.

The largest shipments during these months were to France and Belgium, although Germany and Italy increased their purchases quite appreciably.

During June no marked changes took place in the coal-export situation but the coke export has almost ceased. The coke situation in Europe is quite acute, but unfortunately whereas the analyses of many cargoes of American coke were perfectly satisfactory, its physical condition on arrival was not satisfactory to European furnaces, as there was an excessive amount of breakage in handling, and unless some method be devised to reduce it to the minimum there is doubt of a renewal of American coke buying in Europe.

Merrill Sails To Arrange for World Power Conference

O. C. Merrill, Executive Secretary of the Federal Power Commission and General Chairman of the committee appointed by twenty-odd American engineering and industrial societies to organize American participation in the World Power Conference to be held in London next July, will sail for London some time this month to discuss the details of such participation with the English organization.

Coal Commission's Report Has Various Reactions

The storm center of the anthracite report of the United States Coal Commission is the recommendation that the President be authorized to declare a national emergency in case of a deadlock between operators and mine workers, and be empowered to take over the operation of mines and the distribution and marketing of the product. The operators fear that this would prove to be nationalization's entering wedge. Labor objects to it because there at least would be the coercion of public opinion brought to bear to make men work against their will. The public, however, seems to regard the measure with favor, not that it is anxious to see the government undertake any business activity, but because it believes the industry will avoid any invoking of the emergency powers and with that alternative hanging over them will reach an agreement.

In some quarters the report of the Coal Commission is criticized for not having made clearer that there was no intention to reflect upon the integrity of the anthracite-producing companies in their comment on the limited natural monopoly. The fact that the nation's deposits of anthracite are limited is not chargeable to the operators. They would be subject to

criticism had they combined to restrict output or to manipulate price, but the report makes no such charges.

Another criticism of the report is that the Commission sidestepped a very important point when it stated that the determination of margins and profits is a judicial function. Before any definite conclusions can be drawn, it is contended, as to whether there has been profiteering, there must be a determination as to whether the properties are to be valued on their original cost, on the income tax basis or on present value.

The report reveals that the Commission believes the public is entitled to sit as an observer in the affairs of business and is very determined in its belief that the government should stay out of the coal business, but it believes it should know what is going on in that industry.

Federal Power Commission Makes Report

The Federal Power Commission has had a total of 425 applications, and has authorized 97 preliminary permits and 105 licenses during the three years of its existence. Of the licenses 42 are for major projects, 19 are for minor projects and 42 are for transmission lines.

Of the 42 licenses covering major projects, the works involved are either constructed or under construction, with the exception of eight instances. It is believed, however, that all but three or four of the 42 projects will go ahead within the time allowed.

With respect to the preliminary permits, however, the progress has not been so marked. Only five of the 97 issued have been followed up thus far with applications for licenses. Twelve of them have been cancelled.

The three-year limit will expire for several important projects next March. Among those is the White River project of the Dixie Power Co. in Arkansas, the Washington Irrigation and Development Co. at Priest Rapids on the Colorado River, where a development of 350,000 hp. was contemplated and the proposed Niagara Gorge development of the Lower Niagara River Power and Water Supply Co., a subsidiary of the Niagara, Lockport and Ontario Power Co. That development is being held up at present by the failure of the State of New York to grant the company the necessary permit.

Rio Grande Development Delayed

No development of hydro-electric power on the Rio Grande may be expected for some time to come. The Federal Power Commission has been compelled to reject a preliminary permit requested by R. W. Morrison, of San Antonio, in connection with his plans to utilize water power for public-utility use in Laredo, Texas.

The proposal was referred to the International Boundary Commission, which has jurisdiction over boundary matters between the United States and Mexico. Gustavo P. Serrano, the consulting engineer for the Mexican section, reported adversely on the project on the ground that it would violate the existing treaty, which provides that the Rio Grande must be kept open for navigation. The State Department concurs in the opinion of the Mexican engineer.

Since no amendment to the treaty can be undertaken when there is no recognition of the existing Mexican Government, it would seem that an indefinite period must elapse before any power development can be undertaken on the Rio Grande.

Pinchot Vetoes Engineers' License Law Repeal Bill

GOVERNOR PINCHOT vetoed the bill recently passed by the Legislature of Pennsylvania, repealing the engineers' registration and license law of 1921. Both legislative and judicial opposition to the law had been raised. Samuel E. Shull, of Stroudsburg, on July 2, handed down a decision in the lower courts that the law creating the Registration Board was unconstitutional.

Publishing House Installs a Diesel Engine

The Doubleday, Page & Co. have at Country Life, Long Island, a complete publishing plant. To furnish heat and power, reciprocating steam engines and boilers were installed at the time the factory was built; this equipment was further increased by the addition of a medium-compression hot-bulb oil engine.

So satisfactory has been the operation of the oil engine, that the owner decided to install a second unit and has purchased a 440-hp. Nordberg vertical two-stroke cycle Diesel direct-connected to a direct-current generator.

Sacramento Seeks To Develop Power on Silver Creek

The City of Sacramento has applied to the Federal Power Commission for a preliminary permit covering a large power, irrigation and water-supply project which will involve the ultimate development of 260,000 hp. in Silver Creek in Eldorado County, Calif.

The city proposes to develop two reservoirs on the headwaters of the Rubicon River. The water then is to be diverted into a large reservoir on Silver Creek. Below this storage reservoir the plans call for three large power houses on Silver Creek.

Sacramento has just completed a large filtration plant, but like San Francisco, Los Angeles and Portland, has decided to go high into the mountains for pure water. The Sacramento project, however, will conflict to a certain extent with the rights of the Western States Gas & Electric Company.

Iron River Plant Buys Diesels

The Peninsular Power Co. has purchased two 1,250-hp. Nordberg, two-stroke-cycle Diesel engines, direct-connected to 1,075-kva. Westinghouse generators, for its Iron River, Michigan, plant. These engines will be located in an extension of the present power house and will serve as a stand-by unit, operating during the months when sufficient water is not available for the demands of the hydro-electric plant.

Ash Content of Anthracite To Be Determined

In order to discover the amount of ash in anthracite as actually delivered to the consumer, the United States Bureau of Mines has sent into the field two engineers with a truck arranged for reducing coal samples, which will be labeled and analyzed later at the Pittsburgh testing station of the Bureau.

The work was started in Massachusetts July 9 and will be continued in the New England States until winter. The co-operation of local dealers is essential as donations of 1,000-lb. samples will be necessary for each test and are to be taken, if possible, from coal being loaded for actual delivery.

Results of these tests will be published by the Bureau at the end of the season, but neither the names of the dealer from whom the samples were taken nor the names of the shipping mine will be disclosed.

As the fund at the disposal of O. P. Hood, the mechanical engineer of the Bureau, is so small, similar tests of bituminous coal cannot be made this season.

Preliminary Permit Granted the Flaming Gorge Project

By granting a preliminary permit to the Utah Power & Light Co. covering its Flaming Gorge project on Green River, the Federal Power Commission has inserted the thin edge of the wedge which is expected to lead to action on the Colorado River projects. Regardless of what Arizona may do with regard to the ratification of the Colorado River compact, it is believed that the Commission will award this Fall the Girand license, covering the large development proposed at Diamond Creek. It is believed that the upstream states could not insist successfully that the Arizona project be held up when they have urged the granting of the Flaming Gorge permit. Prominent officials of both Utah and Colorado now are on record in vigorous fashion urging the granting of that permit.

The load of the Utah Power & Light Co. has been increasing at such a rate that a steam auxiliary must be put into operation in the near future. Un-

less the Flaming Gorge development is allowed to proceed as rapidly as possible, it will be necessary to construct additional steam units. It is to avoid this latter situation that so much pressure has been brought to permit the company to proceed with its foundation explorations at Flaming Gorge.

Wisconsin Legislating for State Water Power

The Wisconsin Legislature, in session at Madison, has before it for consideration a bill which will amend the state constitution so as to permit the state to go in debt, by issuing securities, in order to buy hydro-electric power plants and water-power sites. The bill has passed the Lower House and is expected to pass the Senate shortly.

Louisville Desires to Develop Water Power at Falls of Ohio

The city of Louisville, Ky., is very much in earnest in its desire to undertake the development of power at the Falls of the Ohio on the Green River. A careful investigation of all the points involved in the conflict between it and the Louisville Hydro-electric Co., a subsidiary of the Louisville Gas & Electric Co., will be undertaken by the Federal Power Commission in connection with these conflicting applications.

The Louisville Gas and Electric Co. has an existing steam installation of 90,000 hp. of which 30,000 has recently been installed, which with its distributing system totals an investment of $20,000,000. It proposes to use this existing system partly as a stand-by to the water power it hopes to develop at the Falls of the Ohio.

The City of Louisville proposes to supplement the Ohio River power by constructing a high dam in the Green River near the Mammoth Cave. It is estimated that the plant at the Falls of the Ohio will cost $10,000,000 and the Green River auxiliary $5,000,000. Sufficient storage is planned to maintain a 100,000-hp. output throughout the year from the combined plants.

The city claims that it will use the power for municipal purposes to some extent but principally to attract new industries, and will not interfere in any way with the existing markets of the Louisville Gas & Electric Co.

Under the water power act the Federal Power Commission must determine the legal competency of the applicant and some doubts are expressed as to the ability of the City of Louisville to undertake this enterprise without exceeding its bonded indebtedness.

With the idea that domestic consumers can determine for themselves whether they are being charged excessive prices for anthracite, the Coal Commission is issuing a statement showing the cost of stove anthracite on dealers' sidings. These figures now are available for places in New England.

New Publications

Tables of Thermodynamic Properties of Ammonia; Circular of the Bureau of Standards No. 142. Paper covers; 7x10 in.; 47 pages; 5 tables; 1 chart. Price, 15 cents.

The Bureau of Standards under the authorization of an Act of Congress, approved in 1912, and at the request of a number of engineering societies, conducted an extensive research into the properties of ammonia. The results of the work are in surprisingly good agreement with the average of the several values established by other investigators. As a result of its labor the Bureau prepared tables based on empirical equations that are consistent both with the laws of classical thermodynamics and with the values established by the extensive experimental work. The circular includes five tables covering the properties of liquid, saturated and superheated ammonia. In addition a Mollier heat chart is included. This chart enables the properties to be obtained without recourse to the tables and in addition lends itself to the working out of various refrigerating problems with the minimum of mathematical computation. The tables on the properties of saturated ammonia appeared in *Power*, Jan. 18, 1922, and a chart based on the Mollier chart, but to a different scale, appeared in *Power*, Sept. 26, 1922. The Bureau is to be congratulated on the thoroughness of the work, and in view of the increasing interest in other refrigerating media it should be urged to prepare similar data on carbon dioxide, ethyl chloride, etc.

Circular of the Bureau of Standards, No. 142—Tables of Thermodynamic Properties of Ammonia. Price, 15 cents. Government Printing Office, Washington, D. C.

Obituary

Robert Woolston Hunt died at his home in Chicago, on July 11, at the age of eighty-four. Funeral services were held in Chicago on July 13 and interment the following day at Troy, N. Y.

On Dec. 9, 1838, Mr. Hunt was born in Fallsington, Bucks Co., Pa., He spent several years learning the practical side of iron making in the rolling mills of John Burnish & Co., Pottsville, Pa., and later took a course in analytical chemistry in the laboratory of Booth, Garrett & Blair. Upon the completion of this he entered the employ of the Cambria Iron Company, of Johnstown, Pa., and for them, on Aug. 1, 1860, he established the first laboratory in America as a direct part of an iron or steel organization. In the fall of 1861 he entered the United States military service and was in command of Camp Curtain at Harrisburg, Pa., with the rank of captain. Upon being mustered out of service, he returned to the employ of the Cambria Iron Co. and was sent to the works at Wyandotte, Mich., where experiments with the new bessemer process of making steel were being conducted. He was placed in charge of the experimental works in July, 1865, and so continued until May, 1866, when the Cambria Iron Co. called him back to Johnstown to take charge of its steel business. It was at this mill later, and largely under Mr. Hunt's direction, that the first commercial

ROBERT WOOLSTON HUNT

order for steel rails ever made in America was rolled.

Later, he assisted in designing and building the Bessemer works of the Cambria plant; in 1873 he moved to Troy, N. Y., to become superintendent of the Bessemer works of John A. Griswold & Co., and in 1875 he became general superintendent of the Albany & Rensselaer Iron & Steel Co. During his years of active connection with steel-rail manufacture he almost completely rebuilt the various works of this company and he also patented many details of iron and steel metallurgical processes and machinery, including, in conjunction with others, the first automatic rail mill tables.

Upon leaving Troy in 1888, he removed to Chicago and established the bureau of inspection, tests and consultation now known as the Robert W. Hunt Company.

Mr. Hunt was twice president of the American Institute of Mining and Metallurgical Engineers, past-president of the American Society of Mechanical Engineers, past-president of the American Society for Testing Materials, and past-president of the Western Society of Engineers. He was also a member of various other technical societies both in this country and Europe. Just one day before his death the Board of Directors of the American Society of Civil Engineers had made him an honorary member.

In 1912 Mr. Hunt was awarded the John Fritz medal (for his contributions to the early development of the bessemer process) and in June of this year he was given the Washington award of the Western Society of Engineers in recognition of his achievements. He was for many years a trustee of the Rensselaer Polytechnic Institute and in 1916 received from it the honorary degree of Doctor of Engineering. He was married in 1866 to Miss Eleanor Clark, of Ecorse. Mich., who survives him.

Personal Mention

Charles R. Main, consulting engineer of Boston, was recently elected a member of the Corporation of the Massachusetts Institute of Technology.

M. H. Harrington, chief engineer, Ancona Mills, Fall River, Mass., is taking a vacation which will include a trip to Colorado and the Coast.

John W. Lane, former editor of *National Engineer*, John P. O'Connor and Fred W. Raven, secretary of the National Association of Stationary Engineers, have returned from their European trip.

Carl D. Jackson, consulting counsel for the N.E.L.A. and the American Gas Association, has opened an office for the general practice of law in the Bar Building, 36 West 44th St., New York City.

Frank B. Carpenter, formerly with the West Virginia Engineering Co., in the design and construction department, has resigned and has been appointed electrical engineer with the J. C. Sullivan mining interests in West Virginia.

Business Notes

The **General Refractories Co.** has opened a sales office at 200 Devonshire St., Boston, Mass. Malcolm C. Sargent will be district sales manager in charge of this office.

The **Green Equipment Corp.**, manufacturers of commutator tools, stones, etc., announces the appointment of Thomas H. Endicott as vice-president and general manager.

The Terry Steam Turbine Co. announces an election of officers: D. H. Thomson, president; Lucius Rossiter, vice-president and treasurer; R. L. Thomsen, secretary and sales manager.

The **Saro Company, Inc.**, manufacturer of steam traps, etc., has elected Clement Wells, New York City, as president, and George H. B. Burke, Western sales manager, Chicago, as vice-president. E. J. Ritchie has been made a member of the board of directors.

The Chain Belt Co., Milwaukee, Wis., announces that William C. Frye, for seven years president of the company, has retired from active participation in its affairs and has been succeeded by C. R. Messinger, who has been vice-president and general manager since 1917.

The **Diamond Power Specialty Corp.**, of Detroit, Mich., announces the following appointments of agents: Burford, Hall & Smith, American Trust & Savings Bank Bldg., Birmingham, Ala., for the Birmingham district; Paul E. Theis, 608 Rockafeller Bldg., Cleveland, Ohio, for that district; Boiler Equipment Service Co., Candler Bldg., Atlanta Ga., for the Georga and Forida districts.

The **A. W. Cash Co.**, of Decatur, Ill., manufacturer of pressure reducing and regulating valves and the Craig damper regulator announces the appointment of the Ashmead-Danks Co., 7016 Euclid Ave., Cleveland, Ohio, to represent it.

Coming Conventions

American Chemical Society, Dr. Charles L. Parsons, 1709 G St. N. W., Washington, D. C. Convention at Milwaukee, Wis., Sept. 10-14.

American Institute of Electrical Engineers, F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast Convention at Del Monte, Calif., Oct. 2-5.

American Institute of Mining and Metallurgical Engineers; F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at Ontario, Quebec, Canada, Aug. 20-31.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Illuminating Engineering Society, H. E. Mahan, Schenectady, N. Y. Convention at Fort William Henry Hotel, Lake George, N. Y., Sept. 24-28.

International Union of Steam and Operating Engineers; Dave Evans, 6334, Yale Ave., Chicago, Ill. Annual convention at Detroit, Sept. 10-15.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Pennsylvania**, at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York**, at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota**, at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Rve. N. E., Minneapolis.

National Safety Council, W. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Twelfth annual congress at the New Statler Hotel, Buffalo, N. Y., Oct. 1-5.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

The New England Water Works Association; Frank J. Gifford, 715 Tremont Temple, Boston, Mass. Annual Convention at Burlington, Vermont, Sept. 18-21.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

Society of Naval Architects and Marine Engineers, Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

Trade Catalogs

Castings—Nugent Steel Casting Co., formerly the Electric Steel Co., Chicago, Ill. Bulletins 1 to 33 covering steel castings.

Turbine, Steam—B. F. Sturtevant Co., Boston, Mass. Catalog No. 311 describes, with valuable illustrations, Type 12 turbine and its care and operation.

Air Pre-heater—James Howden & Co., of America, Inc., Wellsville, N. Y. Bulletin No. A-5 describes and gives pictures of installations as well as sectional views of the pre-heater.

Pumps, Multistage Centrifugal—De Laval Steam Turbine Co., Trenton, N. J. Catalog H, describing a series pump made with two or three stages, is liberally illustrated with photos and takes up the methods of construction.

Compressors, Steam-Driven Air — Ingersoll-Rand Co., 11 Broadway, New York City. Form No. 3044. Describes, with numerous illustrations, the "Imperial" type XPV duplex steam-driven air and gas compressors equipped with I-R plate air valves.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	July 9, 1923	July 16, 1923
Pool 1,	New York	$3.25@3.75	$3.25@3.75
Smokeless,	Columbus	3.00@3.50	3.00@3.50
Clearfield,	Boston	2.00@2.50	2.00@2.75
Somerset,	Boston	2.25@2.75	2.25@3.00
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	1.80@2.00	1.90@2.10
Franklin, Ill.	Chicago	2.75@3.25	2.75@3.25
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.50@1.85	1.50@1.90
S. E. Ky.,	Louisville	1.50@2.25	1.75@2.25
Big Seam,	Birmingham	1.85@2.25	1.75@2.15

FUEL OIL

New York—July 19, light oil, tank car lots, 24@28 deg. Baumé, 4c. per gal.; 30@34 deg. 4c. per gal., f.o.b. Bayonne, N. J.

Chicago—July 14, 24@26 deg. Baumé, $1.97 per bbl.; 32@36 deg., $2.27 per bbl., tank cars.

St. Louis—July 10, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.80 per bbl.; 26@28 deg., $1.85 per bbl.; 28@30 deg., $1.90 per bbl.; 32@36 deg., gas oil, 4¾@5c. per gal.; 36@40 deg., distillate, 5c. per gal.

Pittsburgh—July 10, f.o.b. local refinery, 30@34 deg., fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 7¼c. per gal.

Dallas—July 14, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

Cincinnati—July 12, tank car lots f.o.b. local refinery, 26@30 deg. Baumé, 4¾c. per gal.; 30@32 deg., 5c. per gal.; 38@42 deg., distillate, 6¼c. per gal.

New Plant Construction

PROPOSED WORK

Calif., Beaumont — The Fruit Growers' Assn., A. E. Isham, Mgr., is in the market for ice manufacturing machinery and cold storage equipment.

Calif., Beverly Hills — The city voted $400,000 bonds for the construction of a municipal water system.

Calif., Carmel—G. G. Moore, 52 Vanderbilt Ave., New York, is having plans prepared for the development of about 25,000 acres in Monterey Co., near here, including construction of irrigation ditches, pumping plants, etc. Cost will exceed $300,000. P. R. Gadd, Forum Bldg., Sacramento, Engr.

Calif., Gilroy — The city plans to vote $90,000 bonds for waterworks improvements.

Calif., Long Beach — The Pacific Steel Corp. plans to build a steel rolling mill on a 200 acre site, here. D. M. Reynolds, First Natl. Bank, 707 South Spring St., Los Angeles, interested. Cost will exceed $10,000,000.

Calif., Los Angeles—The Crescent Creamery Co., 237 Winston Ave., is having plans prepared for the construction of a 2 story, 100 x 200 ft. milk plant, 1 story, 80 x 80 ft. boiler house and a 2 story, 93 x 200 ft. ice cream plant on Slauson Ave. Morgan, Walls & Morgan, Van Nuys Bldg., Archts.

Calif., Los Angeles—J. Toplitzky, I. W. Hellman Bldg., is having preliminary plans prepared for the construction of an 11 story, 105 x 120 ft. office building on Spring and 7th Sts. Estimated cost $1,000,000. Schultz & Weaver, 17 East 49th St., New York, Archts.

Calif., Manteca—The South San Joaquin Irrigation Dist. will hold an election to vote $500,000 bonds for ditch lining and purchase of pumps for drainage works.

Calif., Martinez—The county, J. H. Wells, Clk., will receive bids until Aug. 6 for furnishing one 50 hp. boiler for county hospital.

Calif., Merced — The Merced Irrigation Dist., R. C. Starrett, Resident Engr., is receiving bids for the construction of an exchequer dam, about 310 ft. high, 900 ft. long on top, over 12 ft. thick at top, and over 127 ft. thick at base, Jorgenson type, slightly modified. Cost between $3,000,000 and $4,000,000. Starr, Thebo & Anderton, Sharon Bldg., San Francisco, Engrs.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared for the construction of a 70 x 100 ft. steam plant, equipped with 1,575 hp. steam boilers (ultimately 7,500 hp.), including shop, etc., on Stevenson St. between 5th and 6th Sts. Estimated cost $250,000. Private plans.

Calif., San Francisco—The Southern Pacific Co., 65 Market St., F. W. Taylor, Purch Agt., will receive bids until July 25 for furnishing electric motors required during year ending July 14, 1924.

Conn., Hartford—The Bd. of Contract & Supply, Municipal Bldg., will receive bids until Aug. 21 (change of date) for the construction of a 3 story high school building, including steam heating plant, on Maple Ave. Estimated cost $1,500,000. E. T. Wiley, 75 Pratt St., Archt. F. I. Cooper Corp., 983 Main St., Assoc. Archts. Noted Apr. 24.

Conn., Middletown—The Standard Oil Co. of New York, 26 Broadway, New York, plans to build a distributing plant, consisting of two buildings, dock facilities, storage tanks, etc. Estimated cost $1,000,000.

Fla., Indian River City—The Indian River City Town Site Corp., H. F. William, Mgr., plans to build electric light and ice plants. Estimated cost $35,000.

Fla., Tampa—The Hillsborough Lodge is having plans prepared for the construction of a 10 story, 103 x 120 ft. masonic temple and office building on West Lafayette and Parker Sts. Estimated cost $700,000. M. L. Elliott, Citizens Bank Bldg., Archt.

Ga., Macon — The Clinchfield Portland Cement Co., Kingsport, Tenn., is having plans prepared for the construction of a cement plant near here. Estimated cost $1,000,000. Private plans.

Ill., Chicago—The Natl. Theater Corp., 7542 Cottage Grove Ave., is having plans prepared for the construction of a 3 story, 84 x 106 x 144 x 183 ft. theater, store and office building, including steam heating system, at 7941-47 South Halstead St. Estimated cost $1,500,000. A. C. Leska and J. Eberson, 212 East Superior St., Archts.

Ill., Joliet—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, Wis., are receiving bids for four 150 lb. pressure boilers, superheaters, stokers and fans, for the Eagle Paper Co., here. Estimated cost $45,000. Noted June 19.

Ind., Cambridge—The Cambridge Light & Power Co. plans to build an electric light and power plant. Estimated cost $50,000. The owner is in the market for machinery and equipment.

Ia., Dubuque—The city awarded the contract for two centrifugal pumps to Dayton-Dowd Co., Quincy, Ill., $5,270 and $3,810, respectively; Venturi meters to F. H. Dorner, 548 Milwaukee St., Wis., $2,250; air lift equipment and two motor driven compressors to the Sullivan Mchy. Co., 124 South Michigan Ave., Chicago, Ill. Noted July 3.

Ia., Manning — A. Dohman, Archt., 68 Wisconsin St., Milwaukee, Wis., is preparing preliminary plans for the construction of a 2 story, 84 x 186 ft. hospital and 40 x 150 ft. power house and laundry, here. Estimated cost $300,000. Owner's name withheld.

Ky., Louisville—The United States Engineer Office, P. O. Box 72, is in the market for one deep well pump, double stroke, belt driven, power head, 8 in. drop pipe, 16 ft. brass strainer and 7½ in. internal diameter cylinder; will receive bids until July 30 for one vertical centrifugal pump to deliver 7,000 g.p.m. against a head of 25 ft., complete with motor base, line shaft, etc., 450 to 575 r.p.m.

Md., Baltimore—The Baltimore News & American, Fayette and Calvert Sts., is having plans prepared for the construction of a 6 story, 60 x 150 ft. newspaper plant on Pratt and Commerce Sts. Estimated cost $750,000. G. R. Callis, Jr. Amer. Bldg., Archt. Engineer not selected for heating and ventilating system. The owner is in the market for high power elevators, conveyor equipment, etc.

Md., Baltimore—Flynn & Emrich, 305 North Holliday St., are having plans prepared for the construction of a foundry, machine, casting and storage building, also boiler house. Estimated cost $75,000. Private plans.

Mass., Middleboro—The Dept. of Public Wks., State House, Boston, is having plans prepared and will soon receive bids for the construction of a 1 story, 22 x 27 ft. power house and dam, to develop 100 hp. on the Nemacket River, here. Estimated cost $20,000, not including equipment. M. H. Merrill Co., 50 State St., Boston, Engrs.

Minn., Lesueur Center—The city, A. A. Tambornino, Clk., will receive bids until Aug. 3 for a motor driven deep well pumping unit, also pipe and fittings for connection with street main. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Engr.

Mo., St. James—The city will hold an election July 31 to vote $45,000 bonds, $33,000 for waterworks and distribution system, and $12,000 for sewer system.

N. J., Pennington—The Borough Council, H. L. Laning, Clk., will receive bids until Aug. 26 for the construction of electrically operated pumping station. Separate contracts may be awarded for building and erection of mechanical equipment. Remington & Vosbury, 601 Market St., Camden, Engrs. Noted July 17.

N. Y., Altmar—The Niagara, Lockport & Ontario Power Co., Marine Bank Bldg., Buffalo, is having plans prepared for additional hydro-electric power development, including power houses, dams, penstocks, surge tanks and electric generating equipment, on the Salmon River, here. Estimated cost $1,000,000. H. C. Church, Ch. Engr.

N. Y., Arverne (Far Rockaway P. O.)—W. H. Gompert, Archt., Bd. Educ., Flatbush Ave. Extension and Concord St., Brooklyn, will receive bids until July 27 for installing heating, ventilating and temperature regulating apparatus for P. S. 42 on Beach, 66th and Thursby Sts., here.

N. Y., Buffalo—The Buffalo Consistory, 1180 Deleware Ave., is having plans for the construction of a 1 and 2 story, 125 x 293 ft. club house and cathedral. Estimated cost $750,000. H. F. Cook, 408 Pearl St., Archt. Equipment detail not reported.

N. Y., Frewsburg—The Greenfield Constr. Co. is in the market for boilers, etc.

N. Y., New Brighton—W. H. Gompert, Archt., Bd. Educ., Flatbush Ave. Extension and Concord St., Brooklyn, will receive bids until July 27 for installing heating, ventilating and temperature regulating apparatus for addition to Curtis High School, Hamilton Ave. and St. Mark's Pl., here.

N. Y., Ossining—C. F. Rattigan, Supt. of State Prisons, Capitol, Albany, will receive bids until July 31 for refrigeration plant, Clinic Building 8, and Building 4; electric elevators, mess hall and kitchen building 4; one 200 kw. d.c. generator set, etc., for Sing Sing Prison, here. S. W. Jones, Capitol, Albany, Archt.

N. Y., Oswego—The state is having plans prepared for the construction of a 2 story, 69 x 213 ft. grain elevator, storage capacity 1,000,000 bu., consisting of twenty-seven circular bins, each 20 ft. diameter, 90 ft. high, with sixteen interstice bins and twenty outside bins; two 24 x 30 ft. movable marine towers, 158 ft. high, running on 20 standard car trucks on pier floor, unloading capacity 16,000 bu. per hour; conveyor system, capacity 20,000 bu. per hour; grain shed; welfare and administration building; machine shop, on River St., here. Estimated cost $1,000,000. State Canal Bd., Albany, Archts. F. La Du, 158 State St., Albany, State Engr., will purchase complete dust cleaning system, consisting of pneumatic cleaners, low pressure conveyors, dust house, etc.

N. Y., Penn Yan—The Penn Yan Boat Co. plans to build 1 story, 80 x 120 ft., 60 x 80 ft. and 60 x 100 ft. plant buildings and boiler room. Cost between $35,000 and $40,000.

N. Y., Rochester—The Rochester Gas & Electric Corp., Clinton Ave., plans to build an electric substation on Lake Ave. Estimated cost $25,000.

N. Y., Sheepshead Bay (Brooklyn P. O.)—W. H. Gompert, Archt., Bd. Educ., Flatbush Ave. Extension and Concord St. Brooklyn, will receive bids until July 27 for installing heating, ventilating and temperature regulating apparatus for P. S. 100, West 3rd St., here.

N. Y., Shushan—The state has had plans prepared for the construction of a dam, 85 ft. high, across the Battenkill River, here, impounding 34,000,000,000 cu.ft. of water. Estimated cost $1,600,000. Hudson River Regulating Comn., Engrs.

N. Y., Watertown—The Power Corp. of New York, Light & Power Bldg., J. N. Carlisle, Pres., is having plans prepared for hydro-electric development of 6,000 hp. at 117 ft. head, including dam, penstock, generating equipment and high tower transmission line, at Soft Maple Dam on the Beaver River, near here. Cost will exceed $500,000. W. P. Creaker, Northern New York Trust Bldg., Watertown, Engr.

N. Y., Wende (Millgrove P. O.) — The Erie County Bd. of Supervisors, Room 29 City Hall, Buffalo, will receive bids until Sept. 4 for the construction of a 2 and 3 story county home and infirmary, including heating and ventilating systems, etc., here. Estimated cost $1,500,000. F. G. and W. A. Kidd, 542 Franklin St., Buffalo. Archts.

Ohio, Cincinnati — The W. Powell Co., 2525 Spring Grove Ave., is having plans prepared for the construction of a power plant and installation of electrical machinery. Estimated cost $35,000. Fosdick & Hilmer, 1703 Union Trust Bldg., Engrs.

Ohio, Cleveland — The Bolivar-Prospect Co., 1004 Prospect Ave., J. L. Free, Pres., is having plans prepared for the construction of a 10 story, 116 x 180 ft. store building and garage, including steam heating system, on Bolivar Rd. and Prospect Ave. Estimated cost $1,000,000. The Watson Co., 4614 Prospect Ave., Archts.

Ohio, Cleveland — The Lake Erie Glass Co., 1874 East 79th St., is in the market for a Nash No. 1 vacuum pump.

Ohio, Cleveland—The Ninth-Chester Co., Natl. City Bldg., S. H. Kleinman, Treas., plans to build a 12 story, 64 x 115 ft. store and office building, including steam heating system, on East 95th St. and Chester Ave. Estimated cost $1,000,000. Engineer or architect not selected.

Okla., Okemah—S. T. Palmer is in the market for electric light and power plant machinery and equipment, including boilers, etc.

Pa., Carlisle—The Carlisle Gas & Water Co. is in the market for machinery and equipment for power plant at North Middleton.

Pa., Delta—The borough plans to rebuild its water-works pumping plant, which was recently destroyed by fire. Estimated cost $25,000. Engineer or architect not announced. The owner is in the market for machinery and equipment.

Pa., Lehighton—The Lehighton Water Co. plans extensions and improvements to its plant and system. Estimated cost $40,000. The owner is in the market for electrically operated pumping machinery.

Pa., Lewistown—The Bd. Educ., G. T. Cooper, Pres., will receive bids until July 30 for heating and ventilating system in Waye St. building and annex; also construction of 1 story, 40 x 50 ft. boiler house. Estimated cost $40,000. Kast & Kelker, Harrisburg, Archts.

Pa., Scranton — Lackawanna Co., W. G. Watkins, Controller, will receive bids until July 30 for furnishing equipment and the construction of reservoir, pump house and complete water system, for tuberculosis hospital at West Mountain. D. Morgan, Connelly Bldg., Engr.

Pa., Sharon—The City Council, F. Shearman, Clk., is in the market for electric pumping machinery and equipment for sewage disposal plant.

S. D., Flandreau—The city voted $26,000 bonds and is having plans prepared for waterworks improvements, including mains, wells and pumping station. Chenoweth, Kennedy & Rettinghouse, Boyce-Greeley Bldg., Sioux Falls, Engrs.

S. D., Presho—The city will receive bids until Aug. 6 for power plant equipment, including two 45 to 55 hp. fuel oil engines, two 37½ kw. ampere generators, exciters and switchboard panels.

Tenn., Memphis—J. E. Stark & Co., Plum St., are having plans prepared for the construction of a 64 x 85 ft. planing mill with electric motors, also machine shop addition.

Tenn., Old Hickory (Shelbyville P. O.)—The E. I. du Pont De Nemours & Co., du Pont Bldg., Wilmington, Del., has purchased site at Old Hickory powder plant and plans to build a fibre silk plant. Estimated cost $4,000,000. Engineer or architect not selected.

Tex., Abilene—The City Comn. will receive bids for a booster pump, to have daily capacity of several million gallons, electric motor driven, between city and Lake Abilene, to take the place of standpipe. Estimated cost $6,000. H. H. Batjer, City Engr.

Tex., Abilene—McMurray College is receiving bids for the construction of tunnels for a heating plant. Cost between $25,000 and $30,000. D. Castle & Co., Engrs.

Tex., Childress—The Childress Light & Ice Co., F. Houston, Mgr., is in the market for generating machinery and other power plant equipment.

Tex., Dallas — The Palace Shop, 2813 Commerce St., G. Henderson, Purch. Agt., is in the market for an electric power elevator.

Tex., Fort Worth—The Trinity Portland Cement Co., Commonwealth Bldg., Dallas, is having plans prepared for the construction of a cement mill, 2,500 bbl. capacity, northwest of here. Estimated cost $1,000,000. E. O. Eckels, Wash., D. C., and R. L. Humphrey, Harrison Bldg., Phila., Engrs. and Archts.

Tex., Houston—The city, c/o O. F. Holcombe, is having plans prepared and will soon receive bids for the construction of a 3 story library building on McKinney and Smith Sts. Estimated cost first unit $200,000, ultimate cost $700,000. W. W. Watkins, 212 Scanlon Bldg., and L. A. Glover, 604 Bizz Bldg., Archts. Equipment detail not reported.

Tex., Rogers—F. Leahy (machine shop), is in the market for a 100 hp. oil engine.

Tex., Sanger — The city voted $55,000 bonds for waterworks, $22,500 for sewers and $17,500 for the construction of an electric light plant. E. L. Dalton, 1915½ Main St., Dallas, Engr. Noted July 3.

Wash., Puget Sound—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Aug. 8 for electric freight elevator for Ammunition Depot, here.

Wis., Colby—The Clark-Marathon County Cheese Co., c/o A. Brehm, is in the market for refrigeration machinery.

Wis., La Crosse—The La Crosse Lutheran Hospital Assn., 1910 South Front St., awarded the contract for the construction of a 2 story nurses' home, also for remodeling boiler house and power plant, to P. Nelson & Co., Newbury Bldg. Estimated cost $66,456. Steam heating contract has been awarded. Noted July 17.

Wis., Waukesha—The Thompson Malted Food Co., Riverside Dr., is having plans prepared for the installation of a generator. F. A. Vaughn, Inc., 290 3rd St., Milwaukee, Engrs.

Wis., Wausau — The McEachron Apartment Co., 812 Franklin St., H. E. McEachron, Pres., is in the market for laundry equipment, including dryers, for proposed 50 x 100 ft. apartment building.

Man., Winnipeg — The Dept. of Public Wks., R. C. Desrochers, Secy., Ottawa, Ont., will receive bids until July 31 for furnishing and installing two boilers, etc., also heating system for Immigration Bldg., here.

Ont., Merritton—The Garden City Paper Co., L. H. Gardner, Pres., plans to build a paper mill. Estimated cost $400,000. Engineer or architect not selected. The owner is in the market for electric motors, etc.

Ont., Niagara Falls—The Niagara Falls Arena, Ltd., plans to build a 258 x 270 ft. arena on Victoria Ave. Estimated cost $55,000. Engineer or architect not announced. The owner is in the market for two 30 ton ice manufacturing units.

Ont., Toronto—The Hydro-Electric Power Comn., 190 University Ave., is having plans prepared for the construction of an addition to transformer station on Davenport St. Estimated cost $150,000. F. A. Gaby, c/o owner, Ch. Engr. The owner will purchase transformers, switches and electrical equipment.

Que., Bryson—The Ottawa & Hull Power Mfg. Co., Hull, J. B. Fraser, Wellington St., Ottawa, Pres., has had plans prepared and will soon receive bids for the construction of a dam, 400 ft. long, across the North Branch of the Ottawa River, here, to include 75 x 450 ft. canal, headgates, etc., power house, 50 mi. transmission line to Ottawa and substation at Ottawa. Estimated cost $1,000,000. W. Kennedy, Jr., 364 University St., Montreal, Engr. The owner is in the market for three vertical shaft turbine units, with generators, exciters, etc., 22,500 hp., also electrical equipment, electrically operated cranes, etc., for power house, here; step down transformers, etc., for distribution of power, 66,000 volts, for substation at Ottawa.

Que., Montreal—Shavers Laundry Co., Ltd., 95 Canning St., is in the market for one 62 hp. steam boiler.

Que., Quebec — The Sisters of Quebec Hospital, 11 Palace Hill, are having plans prepared for the construction of a 3 story hospital, including steam heating system. Estimated cost $600,000. Stevens & Lee, 62 Charles St., Toronto, Archts.

CONTRACTS AWARDED

Ala., Birmingham—The Highland Apartment Co. awarded the contract for the construction of an 8 story, 100 x 195 ft. apartment house on Highland Ave. and Elm St., to Smallman & Brice, 1115 Ave. E. Estimated cost $800,000. W. L. Denham, Archt., Empire Bldg., will purchase steam heating system.

Ark., Van Buren—The city awarded the contract for filtration plant, pump house and laying of mains to the Ajax Constr. Co., Oklahoma City, Okla., and J. S. Terry, Poteau, Okla. Estimated cost $67,911. Noted June 26.

Calif., Los Angeles—The County awarded the steel contract for the construction of the Hall of Justice Bldg., to W. B. Kyle, I. W. Hellman Bldg. Estimated cost $802,900. Equipment detail not reported.

Calif., Los Angeles — The Professional Bldg. Corp., c/o W. S. Hebbard, Archt., I. W. Hellman Bldg., awarded the contract for the construction of an 8 story store and office building on St. Paul and 6th Sts. to the Winter Constr. Co., Railway Bldg., Los Angeles. Estimated cost $750,000. Equipment detail not reported.

Calif., Oakland—The Pacific Gas & Electric Co., 445 Sutter St., will build a 1 story substation on 50th Ave. near Clark St. Estimated cost $31,000.

Calif., San Jose—The County of Santa Clara awarded the contract for a refrigerating and ice making plant at the county hospital to the Cyclops Iron Wks., 837 Folsom St., San Francisco. Estimated cost $6,149. Noted July 17.

Ill., Cahokia—The Union Electric Light & Power Co., 12th St. and Locust Blvd., St. Louis, Mo., awarded the contract for steel work in second unit of power plant, here, to the Fort Pitt Steel & Iron Wks., Fulton Bldg., Pittsburgh, Pa., $350,000; also two 40,000 hp. turbines, one to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., the other to the General Electric Co., River Rd., Schenectady, N. Y., about $1,000,000 for both. Noted Jan. 16.

Md., Baltimore—B. L. Brown awarded the contract for the construction of a 10 story, 70 x 132 ft. apartment house on Charles and 34th Sts., to the Weller Constr. Co., 816 14th St., Wash., D. C. Estimated cost $850,000. The contractor will award the contract for installation of heating and ventilating systems.

Mass., Boston—The Old Colony Trust Co., 17 Court St., awarded the contract for the construction of a 9 story bank and office building at 28-36 Cornhill St., to A. C. Whitney, 126 State St. Estimated cost $1,000,000. Steam heating system will be installed.

Minn., Emmons—The city awarded the contract for wells, pumps and steel tank to the Gjellefald-Chapman Constr. Co., Forest City, Ia., $13,950, laying sewer and water main to O. Johnson, Alden, Iowa, $17,000. Noted June 19.

Mo., St. Louis—The Bd. of Public Service, City Hall, awarded the contract for boilers for power plant at the St. Louis Training School for Feeble Minded, Scott Farm, to the F. E. Newberry Electric Co., Century Bldg. Estimated cost $22,475. Noted June 12.

N. Y., Jamestown—The Hotel Jamestown, Inc., 3rd and Cherry Sts., awarded the contract for the construction of a 10 story hotel to the Hunkin-Conkey Co., New Century Bldg., Cleveland, Ohio. Estimated cost $862,893 ($422,500 general contract, $440,393 subcontract work). Equipment detail not reported. Noted June 12.

N. Y., New York—The Otto Realty Corp., c/o Rouse & Goldstone, Archts., 512 5th Ave., will build a 12 story, 100 x 125 ft. apartment house at 251 West 80th St., by day labor. Equipment detail not reported.

N. C., Greensboro—The Agricultural & Technical College awarded the contract for the construction of power house and laundry building to the Palmer-Spivey Constr. Co., Elizabeth Ave., Charlotte, $38,450; heating plant to B. MacKenzie, Greensboro, $125,000. Noted June 19.

Ohio, Cleveland—The Bd. Educ., F. G. Hogen, Dir., awarded the contract for the construction of a 1 and 2 story, 172 x 306 ft. and 33 x 78 ft. elementary school and boiler house at 4091 East 146th St., to C. Peterson Co., 4500 Euclid Ave., $483,000; steam heating system to Feldman Bros., 10309 Barrett Ave., $73,243; 1 and 2 story, 172 x 306 ft. and 33 x 78 ft. elementary school and boiler house at 10800 Sandusky Ave., to the Drummond-Miller Co., 7500 Euclid Ave., $493,585; steam heating system to Feldman Bros., $73,243.

Ohio, Cleveland—The Brodhead-Garrett Co., 2835 East 51st St., (hardwood lumber), J. C. Rash, Asst. Secy., awarded the contract for the construction of a 1 story, 300 x 360 ft. warehouse, 40 x 40 ft. dry kiln, 40 x 50 ft. planing mill, 40 x 50 ft. boiler house, office and garage on East 71st St., along tracks of Belt Line R.R. to the C. Peterson Co., 4500 Euclid Ave. Estimated cost $150,000. Former contract rescinded. Noted June 26.